ELECTRICITY

Report on the 2000 research programme

Roland Brüniger

roland.brueniger@r-brueniger-ag.ch

Compressed-air system in an industrial company

Approximately 150,000 compressed-air systems in Switzerland consume around 750 GWh of electricity each year. If present-day know-how were to be used consistently, it would be possible to save an annual total of more than 100 GWh.

Programme priorities and objectives for 2000

Electricity plays an essential role in all areas of daily life. The Swiss Federal Office of Energy's **Electricity** programme supports the optimal use of electricity in specific areas, ranging from generation and distribution to efficient use, though its focus is clearly on promoting *efficient and economical use of electricity*.

Following the definition and fine-tuning of the **four priorities** for the past two years (*energy and information technology, electric drives and motors, electricity distribution* and *high-temperature superconductivity*) and the establishment of trend-watching and support groups, the **main objective for 2000** was to coherently summarise the overall *electricity* concept for the period from 2000 to 2003 based on the various findings.

In the area of **distribution**, work was commenced on the initiation of specific projects based on the findings from corresponding sub-projects. However, the initiation of such projects has grown more complex and time-consuming as a result of the ongoing process of market liberalisation. Furthermore, efforts were made to intensify the involvement of specialised institutes of technology.

In the area of **high-temperature superconductivity in energy technology**, the focus was shifted onto studies and information activities due to the limited availability of funds.

Further progress was made with the establishment of a competence centre that was set in motion last year and focuses on **energy and information technology**. By establishing new international contacts, this institution was able to spread various issues relating to energy efficiency further afield and thus to support it more effectively. One of its more important activities was to conduct a study of the growth of energy consumption in private households as a result of the increasing use of networking.

As before, in addition to achieving a higher level of efficiency, efforts in the area of **drives and motors** were aimed at co-ordinating and harmonising activities concerning the design tool, OPAL, and at promoting energy-efficient drives.

Due to the reorganisation of the Federal Office of Energy and related changes in its personnel structure, securing internal specialised know-how was another major objective for the year under review.

Tasks accomplished and results obtained

DISTRIBUTION

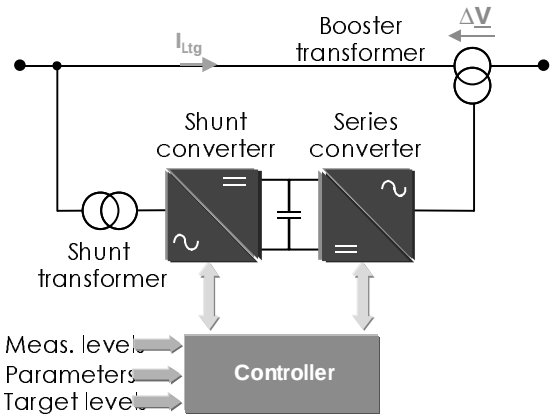
The liberalisation of the Swiss electricity market is progressing at a rapid pace, and both the political sector and the various involved institutions and companies concerned are strongly focusing their attention on this important development. Recent reports from the USA, and in particular from California, have demonstrated that this process is also associated with certain risks and that critical supply shortages have arisen at peak times as a result of inadequate planning. Although this does not apply in Switzerland, discussions with representatives from the electricity industry have revealed similar tendencies with a short-term orientation. As planning horizons generally grow shorter, interest in research projects with a longer-term orientation is also waning.

One of the consequences of this trend is that the PSEL (Project and Study Fund of the Electricity Industry) is currently undergoing reorganisation and will have to reorient itself [17]. It is to be hoped that this important institution within the industry will not be lost to us, despite liberalisation and pressure on prices.

In a liberalised market, non-discriminatory cross-border transmission prices form the basis for the development of a smoothly functioning European electricity market. A **study on methods of pricing cross-border electricity transmission** [1] has been initiated and jointly financed by the Swiss Federal Office of Energy and the *European Commission for the Regulation of Electricity and Gas* (CREG).

The goal of the **Development of system-oriented FACTS elements** (***F**lexible **AC T**ransmission **S**ystem)* [2] was to develop FACTS elements with optimal economic efficiency. Examples of the elements to be developed include a unified power-flow controller (UPFC) that permits independent control of effective and reactive power flows as well as voltage regulation (cf. diagram), and *Advanced Series Compensation* (ASC), which can be integrated into a network without a transformer and forms the technological basis for the realisation of operating resources with UPFC properties.

From the hardware construction of power electronics components through to the integration of controls for the overall system into the network operation line, economic FACTS elements were studied by minimising primary technological installations, optimal FACTS element functions and arrangements in the network were determined independently of typical network configurations and procedures for optimising network behaviour were studied and defined.



FACTS element: a unified power flow controller

The pace of progress of activities within the **FlyWiP** *(**Fly**wheel Energy Storage for **Wi**nd **P**ower Generation)* [3] project that forms part of the European JOULE programme was varied. Most of the components of the flywheel storage unit (cf. photo below) with an energy content of 15 kWh, a maximum capacity of 1 MW and a speed of 15,000 rpm, have meanwhile been developed, though a lot of work remains to be done in certain areas.

Flywheel energy storage unit for use with wind power generators

Although the Swiss partner in the project assumed additional responsibilities alongside its own commitments within the consortium, a decision was taken together with the EU Commission to terminate the project prematurely, but the various tasks will probably be continued outside the framework of the EU project.

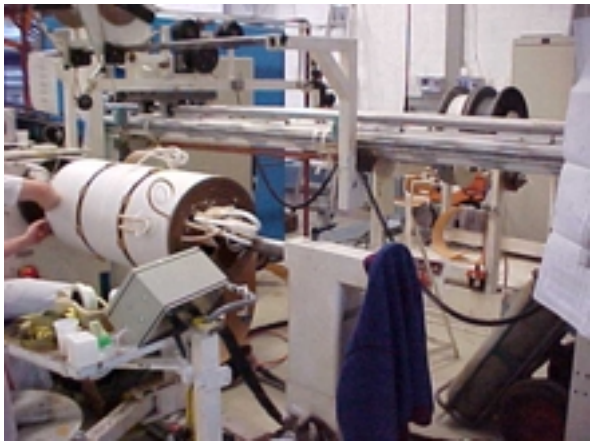
Research activities are being carried out in various areas relating to transmission and distribution technologies at the two Federal Institutes of Technology in Zurich and Lausanne [20, 21].

The following section on *high-temperature superconductivity* also contains descriptions of components that are associated with the *distribution of electricity*.

HIGH-TEMPERATURE SUPERCONDUCTIVITY (HTSC)

The future direction of research in this area was definitively defined on the basis of the study called **High-temperature superconductivity in networks** [4]. Due to the limited funds available, the focus here is being shifted to an increasing extent in the direction of information processing and relaying, and study projects.

The objectives of the **10 MVA high-temperature superconductor transformer** project that was initiated in 1998 consisted in carrying out studies and designing and constructing a transformer with high-temperature superconductor coils (cf. photo below) and integrated short-circuit current limitation. The transformer is intended to have a capacity of 10 MVA, a primary voltage of 63 kV and the capability to control voltage under load. In order to achieve short-circuit current limitation, a new high-temperature superconductor with special properties will be required.



Equipment for HTSC prototype coils

In addition, a parallel project was carried out with the aim of developing conductors, but unfortunately it revealed that the attainable conductor quality fell far short of the required level. Here the main problem was to be found in technical difficulties relating to the production process. Since there was no indication that an acceptable solution is to be found in the near future, but a suitable conductor is vital for the HTSC transformer project, the decision was taken to stop work for the time being. However, the findings that have been obtained to date will of course be extremely valuable for future activities in this area.

Due to lack of interest on the part of the industry, it was not possible to carry over the results of the study on *high-temperature superconductor cables for energy technology* (which was completed in 1999) into a follow-up project.

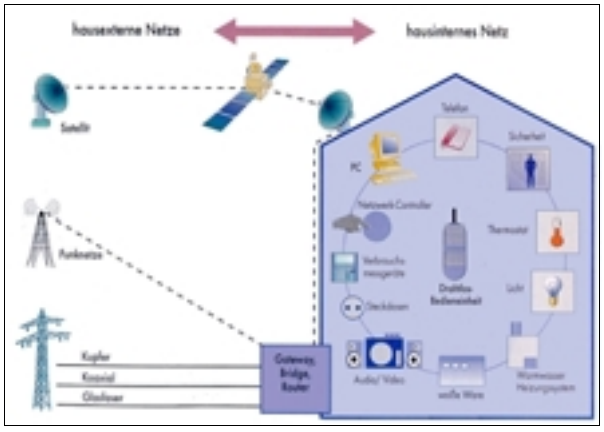
The *IEA programme,* ***Assessing the impacts of high-temperature superconductivity on the electric power sector*** [6], that has been running for 10 years now, was extended by a further three years. As before, Switzerland is an active partner in this programme. In the year under review, a report was prepared on the status and progress of work in the area of AC losses, and a second report on flywheel storage with superconductor units is close to completion. Finally, preliminary work has commenced on a demonstration project for an HTSC energy storage installation.

APPLICATION / EFFICIENT USE

a) Energy and information technology

Electronic equipment is penetrating the market at an ever-growing rate as a result of rapid progress in all areas of information and communications technology, falling prices despite a constant expansion of functions in the latest generations of equipment, and a general trend towards digitisation. For some time now, this trend has no longer mainly concerned professional users in the industrial, commercial and services sectors, for private consumers too are exploiting the technical potentials of modern-day information and communications technology to an ever-increasing extent.

On top of this, the onset of networking of appliances and systems within private households that has already been predicted by experts for a number of years seems increasingly probable as private use of the Internet continues to gain momentum (cf. diagram below depicting an example of networking in a private household). The fact that various media are being brought ever closer together is both a trigger as well as a first visible sign of this trend. The development of ever more user-friendly man-to-machine interfaces, the availability of new services and, last but not least, the possibility of gaining access to household systems and controlling them from any external location will undoubtedly promote the use of networks and intelligent control systems in the not-too-distant future.



Private household with external and internal networks (Source: Fraunhofer Gesellschaft – Project in a house in North-Rhine Westphalia)

A project entitled **Networking in private households** [7] was carried out in order to estimate the impacts of this trend on energy consumption. It was estimated that the level of electricity consumption in private households would increase by a maximum of 1.3% p.a. over the next 20 years as a result of the growth of networking. Even if the effective increase in consumption turns out to be only half this estimated figure, networking is likely to become the most important factor in the growth of electricity consumption in industrialised countries.

The tasks of the **Energy and Information Technology Competence Centre** [7] are focused on the collection, processing and distribution of relevant national and international data concerning these topics. Furthermore, this institution is evaluating research topics with an orientation on practical implementation, and is supporting – and in some cases also carrying out – research projects.

After it had previously been put on hold for personnel reasons, the **Survey of the behaviour of end-users with respect to switching PCs on and off** project [8] was carried out in the middle of 2000 in a mid-sized company with approximately 50 PC users. It was found that, in the company concerned, most users switch off their PC each evening and at weekends. Many of them were sceptical about the use of an automatic switching device (*Wake-on LAN*) or were against the idea altogether, and in general they were inadequately informed about the power consumption of PCs. While these findings may not be representative, they will be useful when it comes to incorporating the results of the survey into other implementation projects.

In order to obtain more representative findings concerning the necessity for network servers to be left on at night and during weekends, a survey by telephone was carried out among 400 small to mid-sized companies in the German-speaking part of Switzerland (**Use of servers in small and medium-sized companies** [9]). Here it was found that around 80% of the companies taking part in the survey possess a data processing network, and the majority of them leave their server on at night (94%) and during weekends and public holidays (90%), even though a quarter of them perform no productive functions at night, and almost 50% of them perform no useful services during weekends/public holidays. Roughly 2/3 of the servers in operation at night perform certain functions and carry out various processes, but these take less than three hours as a rule. The main finding from this survey was that more than half the companies concerned stated they would be in favour of an automatic switching system. From this it can be concluded that there is considerable scope for in-

troducing such systems in network servers. The question whether this room for manoeuvre can in fact be exploited be practice depends on the availability of fully-developed solutions and, above all, on the extent to which it is possible to convince the relevant decision-makers of the technical feasibility, ecological desirability and economic benefits of such systems.

b) Power and electric motors

The electricity statistics published by the Swiss Federal Office of Energy do not provide any explicit details about the proportion of consumption attributable to electric drives, though earlier figures have cited a level of around 40%. However, recent surveys and estimates carried out in Germany and the USA indicate that this may be too low. In Germany, the proportion of electric drives to overall electricity consumption is estimated at ~50%, while the corresponding figure for the USA is as high as ~60% - a level that is particularly attributable to the widespread use of air-conditioners. If we assume that circumstances in Switzerland are similar to those in Germany, we have to conclude that the proportion here is probably somewhere in the region of 45-50%. As before, this high level leaves considerable potential for saving electricity.

A variety of studies have confirmed this assumption: in particular, a study carried out on behalf of the German government and which set out to examine *measures aimed at promoting efficient energy use in the area of electric motors* [14] provides a useful overview .

OPAL: design tool for energy-efficient motors

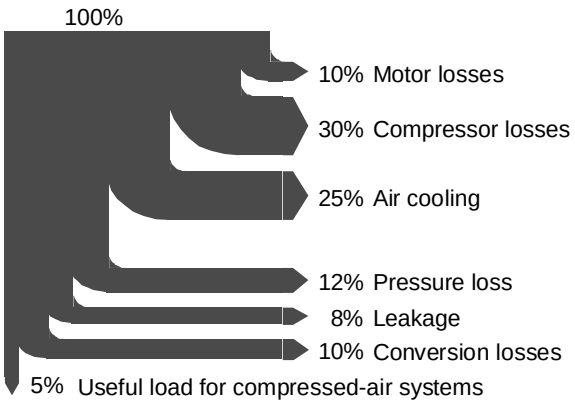
The initially fruitless negotiations held with the EU Commission in 1999 concerning the joint marketing of an expanded version of the *OPAL* design tool for motors were reinstated in the year under review. Intensive talks led to agreement on the majority of points, and the resulting draft contract is currently being examined in depth. It is to be hoped that the EU Commission will give its approval before too long so that it will be possible to start marketing this tool.

In order to draw greater attention to energy efficiency in the area of electric motors and increase the degree of transparency, it would be useful to collect all the relevant data and store them in a comprehensive database. The aim of a project called **Market studies on the establishment of a testing centre for drive systems** [10] (cf. photo below) was to identify how much interest the relevant market players might have in the creation of such an institution, and whether it would be possible to firmly establish it in this market.

Testing device of a Swiss manufacturer of electric motors

The result of this survey among 170 market players has to be regarded as somewhat disappointing: it appears that neither suppliers nor users are seriously interested in a database or a testing centre for drive systems. For this reason, a number of new ideas are currently being developed with the aim of promoting energy efficiency in the area of drive systems by increasing the degree of market transparency.

A study called **Energy efficiency in compressed air systems in Switzerland** [10] revealed that approx. 150,000 such systems consume around 750 GWh of electricity each year, which is equivalent to roughly 1.5% of Switzerland's overall consumption. Compressed-air systems in industrial and commercial companies account for up to 25% of operational power consumption. Pneumatic processes often have a low level of overall efficiency (cf. diagram), and in economic terms it would still be possible to attain energy savings of between 5% and 50%. With more efficient compressed-air systems it would be possible to save around 300 GWh p.a. in theory and 100 GWh in practice. The measures proposed in this study are of particular economic relevance to some 10,000 larger compressed-air systems (i.e. with capacities of 15 kW and over).



Energy flow of a compressed-air system

Compressed-air systems are complex and call for a high level of technical and market know-how. A specialised institute of technology would be a suitable independent competence centre for compressed-air technology, and for this reason efforts are currently being made to establish an institution of this kind.

The European Commission (DG Transport and Energy) intends to launch a *Motor Driven Systems Challenge (MDSC) programme* in order to implement the existing know-how in the industry on increasing the energy efficiency of motors/electric drives on a large scale. Thanks to its international contacts, Switzerland was able to participate in the preliminary stage and will be on the starting-line when the programme is launched in 2001. As a result of its participation, Switzerland will be able to approach the important task of putting the available findings into practice more quickly through its co-operation with a large number of countries (including France, the UK, the Netherlands, Italy, Norway, Sweden, Germany, Greece and Ireland). The MDSC programme will focus on three systems: compressors, pumps and ventilators.

c) Miscellaneous

The European programme, *COST 244b: biomedical effects of electromagnetic fields*, will shortly be drawing to a close, but plans are in place to extend it. Further details may be called up on the Internet [18].

Scientific studies on the phenomenon of sensitivity to electricity were conducted within the framework of a project called *Nemesis* [16].

Finally, the Federal Council brought its "NIS" ordinance on protection against "electro-smog" into effect on 1 February 2000.

National and international co-operation

The convening of periodical meetings of the various specialised *trend-watching/support groups* means that co-ordination and co-operation between the industry, universities and the Federal Office of Energy have meanwhile been secured, and plans are now in place to reinforce these activities by enlarging the field of participants. Initial responses from new interested parties have so far been encouraging.

A brief analysis of the various projects carried out over the past few years has revealed that for every 1 Swiss franc invested by the Federal Office of Energy, 4 Swiss francs have been contributed by third parties (primarily within the industry). This ratio clearly demonstrates the high level of commitment on the part of the industry, as well as the fact that the Federal Office of Energy only provides subsidiary financial support.

Periodical contacts are also maintained with *other Swiss sponsors in the area of electricity*, most notably the *PSEL* (*Projects and Studies Fund of the Electricity Industry*) and the *Commission recherche, développement, prospective de la Chambre romande d'énergie électrique* (RDP-CREE).

An international exchange of information in the area of *high-temperature superconductivity* is primarily maintained through participation in the corresponding *IEA programme*.

In the area of *energy and information systems*, major efforts are being made to maintain contacts with partners in the international arena. For example, the programme head attended a number of events, including the three-day EU Conference on the Energy Efficiency of Household Appliances and Lighting Equipment, and was able to establish valuable contacts as well as exchange up-to-date information [15]. The *Energy and Information Technology Competence Centre* also contributes towards the establishment of contacts and exchanges of information. Finally, Switzerland's membership of the international *Group for Efficient Appliances (GEA)*, which promotes efficient electricity use in the areas of household electronics and office equipment, is also worthy of mention here.

In the area of *electric drives and motors*, the successful completion of negotiations concerning the marketing of OPAL is a good example of sound international co-operation. Furthermore, it is pleasing to note that Switzerland is able to play an active role in the international Motor Challenge programme.

Pilot and demonstration projects

TRANSMISSION / DISTRIBUTION HIGH-TEMPERATURE SUPER-CONDUCTIVITY

Findings obtained from a variety of research projects initiated by the Swiss Federal Office of Energy were subsequently presented to a broader public in the form of special reports and lectures. In particular, the results of the FACTS project were brought closer to the electricity industry through publication in specialised journals and on the occasion of a separate seminar.

The reports resulting from the *IEA Implementing Agreement on high-temperature superconductivity* were forwarded to a variety of interested parties.

APPLICATION / EFFICIENT USE

a) Energy and information technology

The establishment of a new energy agency (the "eae") comprising relevant associations from the household appliances, electronic entertainment equipment, IT and lighting sectors, gave rise to a variety of new contacts that are of particular importance since the agency is an important element in the implementation process.

A big bank has developed a program for optimal energy management based on the NT 4.0 operating system. The programme head has contacted representatives of the bank concerned in order to clarify whether it would be possible to make this software available to third parties.

In order to obtain a comprehensive summary of the various activities, the final report of the **Switching of servers** project [11] is to include the findings from two other projects: *AC Manager: P+D project in the federal administration*, and *Networking of servers in small and medium-sized companies***.**

AC Manager for switching servers (Federal Office of Energy pilot system)

With these projects it was possible to demonstrate that it is possible to switch servers off (cf. photo) at night and during weekends both in a federal agency and in a small-sized company, and that this leads to substantial energy savings. The two solutions were realised using different technologies, and as before are still in their prototype stage. The aim of this report is to encourage the industry to commercialise these systems based on the findings from these two pilot installations by implementing them directly on servers. Discussions to this effect have already taken place, but it has to be stated that the industry still tends to view the idea with a certain amount of scepticism.

b) Power / electric motors

A number of pilot and demonstration projects are planned for this area, but for various reasons they will only be initiated in 2001. Discussions with representatives from the industry have indicated that they tend to only attach secondary importance to this topic.

c) Miscellaneous

At present the Swiss Federal Office of Energy only has limited statistics at its disposal with respect to the ongoing changes in the consumption of electricity by the various user categories. For this reason it decided to carry out two **feasibility studies** in various sectors to identify the potential data sources, procedures for collecting and processing data and the associated once-only and recurring costs. The first report dealt with the **lighting, household technology, mobility and commercial applications** [12] sectors, while a parallel study concerned **household appliances, electronic entertainment equipment, office and communications technology** and **industry (motors)** [13]. These eight sectors account for around 80% of overall electricity consumption, and this means that the Federal Office of Energy has sufficient decision-making material at its disposal in order to refine statistical data in the relevant segments.

As before, the Electricity programme maintains its own *Internet homepage* [19] in order to secure efficient distribution of the results of projects and studies. All reports may be downloaded free of charge from this site in the form of PDF files.

The concept of new types of cooker hotplates would undoubtedly lead to benefits in terms of energy efficiency, but during the year under review the company entrusted with carrying out **field tests for high-performance cooking systems** went bankrupt as a

result of various management problems, and the industry concerned also began pulling out of the project. Under these circumstances it was no longer possible to proceed with it, and the Federal Office of Energy consequently had to abandon it.

Summary for 2000 and outlook for 2001

The Electricity programme was able to achieve its goal of drawing up a coherent *overall electricity concept* based on the four defined priorities. Its concept report was completed in the autumn and is to be presented to CORE (Federal Energy Research Commission) at the beginning of 2001.

It is pleasing to note that we were able to extend the *IEA Implementing Agreement on High-Temperature Superconductivity* for a further three years. The fact that the ambitious project concerning an *HTSC transformer in the 10 MVA range* had to be abandoned was a less positive development. At least we were able to determine that the process of manufacturing long cables in the AC area is still associated with considerable difficulties. Plans are in place to initiate new *system studies* in the area of *HTSC* in 2001.

Unfortunately we were not able to achieve our goal of initiating a project aimed at integrating forms of energy production based on renewable resources into the distribution network, but preliminary work is now in progress and a comprehensive project is to be launched during 2001 with the collaboration of a number of electricity companies and the industry, as well as institutes of technology.

In the area of *energy and information technology* we were able to obtain findings from a study on networking in households that are of interest to an international public and can be used as the basis for specifying regulatory measures. It is therefore important that these findings are passed on to a broad international public. The results of the survey carried out among small and medium-sized companies with respect to switching off servers at night and during weekends are also due to be more widely distributed next year. In order to achieve efficient implementation, we also intend to work more closely together with the recently established *energy agency*.

We were unable to prevent the collapse of the ***Field tests on high-performance cooking systems*** as a result of the bankruptcy of the main industrial partner, despite various efforts and interventions on the part of the programme management. It is to be hoped that the relevant branch of the industry will pursue the development of this technology that promises to yield attractive benefits.

The fact that the agreement with the EU Commission concerning the *OPAL design tool* is close to conclusion can certainly be regarded as a positive development. And it was also important for us to be able to participate in the preliminary tasks for an *international project for the promotion of efficient motors*. Unfortunately the degree of success to date in implementing new findings in the field of *electric drives* and testing them in P+D projects has been rather modest to date, so it is important to reinforce efforts in this direction.

List of projects

(AR) 2000 annual report (available)
(FR) Final report (available)
All reports may be called up via http://www.electricity-research.ch.

[1] H. Glavitsch, *Nussbaumen*: ***Study on methodologies for establishing a system for cross-border tariffication in the internal electricity market*** (AR)

[2] D. Westermann, ABB HOCHSPANNUNGSTECHNIK, *Zurich*: ***Entwicklung neuer systemorientierter FACTS-Elemente*** / ***Development of new systems-oriented FACTS elements*** (FR)

[3] P. von Burg, ASPES, *Zurich*: ***Flywheel energy storage for wind power generation FlyWiP*** (AR) http://www.flywip.com

[4] G. Schnyder, ABB SÉCHERON, *Geneva*: ***Systemstudie "Hochtemperatur-Supraleitung im Netz"*** / ***High-temperature superconductivity in networks – a systems study*** (FR)

[5] H. Züger, ABB SÉCHERON, *Geneva*: ***10 MVA-HTSL-Transformator*** / ***10 MVA HTSC transformer*** (FR)

[6] G. Véscey, EPF *Lausanne*: ***Assessing the impacts of high-temperature superconductivity on the electric power sector*** (AR)

[7] B. Aebischer, FIT *Zurich*: ***Betreuung des Kompetenzzentrums Energie- und Informationstechnik*** / ***Operation of the Energy and Information Technology Competence Centre*** (AR) ⬩ ***Networking in private households*** (AR/FR) http://www.cepe.ethz.ch

[8] S. Frauenfelder, L. Bernays, LINDER KOMMUNIKATION AG, Zurich: ***Untersuchung des Verhaltens von Endbenutzern bezüglich Ein- und Ausschalten von PCs*** / ***Study of the behaviour of end-users with respect to switching PCs on and off*** (FR)

[9] M. Gubler, M. Peters, IPSO – a competence centre of IHA-GfM, *Duebendorf****: Servernutzung in Klein- und Mittelbetrieben*** / ***Use of servers in small and medium-sized companies*** (FR)

[10] R. Gloor, GLOOR ENGINEERING, Sufers: ***Marktuntersuchung für ein Prüfinstitut Antriebssysteme ⬩ Energieeinsparungen bei Druckluftanlagen in der Schweiz*** / ***Market study for a testing centre for drive systems ⬩ Energy savings in compressed-air systems in Switzerland*** (FR)

[11] A. Huser, ENCONTROL, *Niederrohrdorf****: Switching of servers*** (FR)

[12] C.U. Brunner, CUB, S. Gasser, E-TEAM, H. Glauser, E A SI, R. Gloor, GLOOR ENGINEERING, S. Lingenhel, E-VIVA, U. Steinemann, INGENIEURBÜRO US: ***Machbarkeitsstudie Datenerhebung in den Bereichen Beleuchtung, Haustechnik, Mobilität, gewerbliche Anwendungen*** / ***Feasibility study on the collection of data in the lighting, household technology, mobility and commercial applications sectors*** (FR)

[13] A. Huser, ENCONTROL GMBH, B. Schaltegger, MEYER & SCHALTEGGER, W. Baumgartner, BASICS*:* ***Machbarkeitsstudie Datenerhebung in den Bereichen Unterhaltungselektronik, Büro- und Kommunikationstechnik, Haushaltgeräte, Industrie (Motoren) / Feasibility study on the collection of data in the electronic entertainment equipment, office and communications technology, household appliances and industrial (motors) sectors*** (FR)

References

[14] J. Reichert, Fraunhofer Institut, *Karlsruhe*; U. Rath, EBÖK, *Tübingen*: ***Massnahmen zur Förderung der rationellen Energienutzung bei elektrischen Antrieben*** / ***Measures to promote efficient energy use in electric drive systems***

[15] R. Brüniger, *Ottenbach*: ***Report on the 2nd EU International Conference on Energy Efficiency in Household Appliances and Lighting,*** September 2000

[16] C. Schierz, C. Müller; FIT *Zurich*; Projekt Nemesis: ***Niederfrequente elektrische und magnetische Felder und Elektrosensibilität in der Schweiz*** (Tagungsband) / ***Low-frequency electrical and magnetic fields and sensitivity to electricity in Switzerland*** (tape recording)

[17] http://www.psel.ch

[18] http://www.radio.fer.hr/cost244/

[19] http://www.electricity-research.ch / http://www.energielabel.ch

[20] http://www.ee.ethz.ch/research/power/index.de.html

[21] http://www.epfl.ch