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Research Programme "Electricity"

1996 Report of the Research Programme "Electricity" of the Swiss Federal Office of Energy

Head of Programme

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On behalf of the

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1. Overview of the programme Priorities for the period from 1996 to 1999

Since the "Electricity" research programme encompasses a wide-ranging field, but the available financial resources are limited, setting clear priorities is vital in order to ensure optimum use of the available funds. The priorities have been defined for the period from 1996 to 1999 in the research concept [15] that was submitted to the Federal Energy Research Commission in spring 1996 and approved by the Federal Office of Energy. Similarly, the commitment on the part of the industry has been declared a prerequisite, since the financial resources of the Federal Office of Energy only suffice to provide supplementary support. The following three priorities have been defined:

Through **efficient energy use**, it will still be possible to exploit a considerable potential for saving energy. Since electricity plays a leading role in a wide range of fields, the spectrum of research activities in this sector is correspondingly broad. The following activities are planned in a differentiated manner and in harmony with other research efforts:

- Promotion and support of national demand side management projects and active participation in the IEA programme in the same field.
- Promotion of research and development in the field of integral motors in the medium capacity range. In addition, support is to be provided for the development of a non-manufacturer-related electric drive design tool. Finally, clearly defined optimisation projects are to receive financial aid.
- Following the successful introduction of a means for minimising losses in electronic office and entertainment equipment, similar measures are to be envisaged with a view to energy optimisation in networks and data processing centres.

The goals of research efforts in the field of **transmission and distribution** are to help bring about a high degree of network availability, especially in the distribution network, alongside maximum network quality and a minimisation of transmission losses. Since practically the entire power consumption is conveyed to the end user via the distribution network, even a reduction of losses in the per mil range leads to considerable savings. Efforts are being made to develop energy-relevant projects at reasonable cost in the field of network management on the basis of national and international research and development work and with the inclusion of the electricity industry.

Finally, as a follow-up to the initial National Research Programme (NFP 30) which expired at the end of 1995, efforts are to be made to ensure that the energy-relevant research work in the field of **applied high-temperature superconductivity** is pursued without interruption.

2. Tasks carried out and results achieved to date

Generation/production

In the field of *hydropower* there are now practically no more technical problems which would prevent an expansion of the use of hydropower. Most of the remaining obstacles to be overcome here involve ecological and economic considerations and approval procedures. For many years now, attempts have been made to counter the shrinking process in the field of small-scale hydropower plants through special government programmes such as DIANE and PACER, various promotion activities at the canton and government levels, and pilot and demonstration projects. For example, the report entitled **Small-scale hydropower plants and water ecology**, which is due to be published shortly, describes the properties of a natural flowing-water ecological system and the impacts on the latter arising from the operation of small-scale hydropower plants. These activities are being summarised and co-ordinated within the framework of the Energy 2000 *Other renewable energies* programme. The 4-year plan published in 1996 [16] contains detailed descriptions of the activities in this field that the Federal Office of Energy is planning and supporting. The main goal is to increase energy production from small-scale hydropower plants through measures such as reactivation, upgrading and expansion of existing plants and the construction of new ones.

In the completed project, **New converter technologies for renewable energy sources based on the example of small-scale hydropower plants** [1], a variable-speed small-scale hydropower plant has been constructed in collaboration with the electricity works of the town of Sion, which adopts the function of a pressure reduction valve between the reservoir and the supply network. The aim here is to prevent energy loss: by means of a reverse-flow pump, a synchronous motor and an extremely efficient converter with a maximum capacity of 50 kW, an estimated 200,000 kWh a year can now be fed back into the network. The converter developed for this project is also being used in photovoltaic installations. Following a variety of publications in 1996, the results of the project have now been transferred for implementation in the *Other renewable energies* programme. Efforts are now being pursued to make a small-scale hydropower plant module for pressure reduction valves available to the industry. Concrete follow-up activities are also being planned in connection with the synchronous motor, which has not yet been optimised from an energy point of view.

The electricity industry is providing considerable financial resources, particularly in the field of larger hydropower plants. For example, around 30% of the available funds of the PSEL (Project and Study Fund of the Electricity Industry) is being invested in the fields of *hydropower and renewable energies*. An example worth citing here is the development of an analysis system by the EFPL and Electricité de France, which permits the measurement and quantification of cavitation erosion.

Storage

In a project supported by the PSEL, efforts are being made to double the energy density of power capacitors. In addition, a variety of activities are being carried out at universities and within the industry in connection with flywheel technology. At present, the Electricity programme is not supporting any projects in this field.

Transmission/distribution

The goal of the **Load specification model for distribution transformers** project [2] is automatic load identification for the projection of the low-voltage mains. By carrying out direct measurements at different times of year and by means of suitable simulation, it is possible to obtain a fairly accurate picture of seasonal network fluctuations using statistical findings. In 1996, the focus was on developing professional user interfaces for the software, and the first test version was supplied to the participating electricity utilities in the autumn of that year.

The aim of the **Energy-saving and utilisation potential of new types of tape core distribution transformers** project [3] is to study the extent to which the transformer and electricity industries are interested in ring core transformers in the distribution network thanks to the development of a new type of manufacturing process, and how much energy-saving potential would result in Switzerland.

Finally, a project involving the EFPL in Lausanne has been in preparation for some time, in which an operating system is to be developed for switching within the distribution network for optimisation, elimination of overload and malfunctions in real time.

Around 25% of the PSEL budget has been allocated to the field of *transmission/distribution*. The energy industry is supporting on-site diagnosis and monitoring of the insulation status of large-scale transformers, online monitoring of output transformers in operation, measurements of corona noise on 380 kV lines, as well as a variety of other projects.

Application/efficient energy use

a) Power/electric motors

After the first prototype in the 3.5 kW capacity range had been completed in the **0.55 kW - 22 kW integral drive with regenerative energy recirculation** project[4], a capacity increase up to 7.5 kW was subsequently achieved, including a network filter integration and the development of hardware and software for a four-quadrant drive. The industry's reactions to the integral drive were extremely positive. Intensive field tests are being carried out by around a dozen companies, with the participation of a wide range of industrial sectors. Printing and textile machines, ventilators, lifts, pumps

and compressors are just a few examples of the broad range of applications for the integral drive.

The pre-requisites for, and limitations to, a possible expansion of OPAL - the energy-optimised motor selection software for variable-speed drives - were examined in a **Feasibility study on the expansion of the OPAL program system with frequency converters** [5]. This study indicates that, in the initial stage, an expansion of the database with a variety of supplier-specific converter products should be waived. However, an expansion could calculate the operating behaviour of a standard motor supplied by a converter at a given load alternation (speed and torque), and in particular determine the energy consumption and capacity factor. It is planned to expand OPAL in this way with the co-operation of the industry.

A new project is currently in the preparation stage, which is intended to greatly increase the poor overall degree of efficiency of small-scale ventilators. The goal here is to double or even treble their degree of efficiency.

The results of the completed Federal Office of Energy project, **Increased utilisation of recuperation brakes on Re 6/6 locomotives** have been complemented by a multiple control function. This permits an optimum load distribution for the Re 6/6 and Re 4/4 (in the case of twin locomotives) together with an increased utilisation of recuperation brakes. The tests were successful, and measurements indicate an additional recuperation of energy amounting to around 90 MWh p.a. and locomotive pair. Economic efficiency calculations indicate a payback of slightly less than 1.5 years. It is to be hoped that Swiss Federal Railways will install this additional control in all its locomotives.

b) Office equipment/data processing networks

Dealing with the no. 1 priority, *energy management in data processing networks*, represents a major challenge. The influence on the part of the federal government is modest, due to the rapid pace of technological progress, ever shorter manufacturing cycles, pressure on prices and margins, and the extensive degree of internationalisation. Nonetheless, attempts are being made in the form of talks and international co-ordination to exercise an influence on future developments and encourage the implementation of power management. Intensive efforts in this direction have led to firm international contacts with PC manufacturers.

The *On-Now initiative* launched by market-leader Microsoft describes a design concept which permits an independent power management for each individual system component (disk, monitor, videocard, etc.). This concept incorporates not only the hardware, but also the operating system and even individual applications. Discussions with the industry have indicated that the market implementation of this concept might be possible in 1997. The *Magic Frame* concept developed by Hewlett Packard - which permits a remote power on/off for PCs on the network - represents a second move in the same direction.

The Federal Office of Energy itself is continuing to attempt to encourage discussion on the problem of *energy and data processing networks* and to sensitise both the general

public and the relevant institutions to this issue, and has published an information brochure in German and English entitled *Efficient Power Management in Computer and Communication Networks*, which describes the anticipated savings potential in data processing networks and a concrete project in the form of a prototype of a power management system for a Novell network. This report has been distributed to around 600 addresses at home and abroad, and the various articles have been positively received in a number of recognised specialist journals (Computerworld, SIA-Magazin, Schweizer Industrie, the English-language PC magazine, Bytes, etc.). In addition, a number of principles have been drawn up which take the particular problems of networks into account for the target consumption criteria.

The preparation of a research project called **Power management in data processing networks** has been in progress for some time, the aims of which are to summarise the various activities in this field in a fundamental form and draw up specific project proposals on the basis of identified gaps in knowledge. The original intention was to entrust a college of technology with these tasks, and a number of institutions expressed their interest, but unfortunately none of them have been able to provide the necessary specialists to date. But other possibilities are now being considered, so that it can be assumed that it will be possible to start this project at the beginning of 1997, at the same time incorporating the latest developments.

As before, the objectives of the **Office for the promotion of efficient energy use in information technology and consumer electronics** [6] are to collect, process and distribute relevant know-how and provide practical support for the various applications. The main focus of these activities has been the management of the IEA project, *Internationally co-ordinated procurement of innovative copiers*. In addition, the development of efficient power management in networks has been a topic of discussion at events organised both at home and abroad.

c) Demand side management

Switzerland is participating in two projects within the framework of the IEA *Demand Side Management* programme. In the *Communications Technologies for Demand Side Management* [17] project, which is due to be completed in spring 1997, the various communication technologies are being analysed and an evaluation model is being drawn up which proposes the most efficient communication media according to clear priorities (customer mix, required functions, etc.). This evaluation model is now being further developed into a software package. The *Development of Improved Methods for Integrating Demand-Side Options into Resource Planning* project is also due to be completed in 1997. The Executive Committee is setting out to draw up preparatory tasks for the increased implementation of the results achieved in 1997.

In the follow-up project, **Priority activities in the field of demand side management: Guidelines for successful marketing** [7], the chosen methodology for identifying priority fields of activity is to be re-examined and developed further. The idea is that additional findings are to be obtained through practical implementation in a number of participating electricity utilities and integrated into a set of guidelines for successful marketing.

Interdisciplinary projects

a) Superconductivity

The planned practical tests with the single-phase transformer and the production of a three-phase transformer were more or less completed in 1996 within the framework of the **High-temperature superconductivity transformer** project [8]. Of note here is the fact that the definitive design of the transformer was studied on the basis of successful dynamic short-circuit tests at Electricité de France and its suitability was subsequently confirmed. The three-phase transformer is to be put into operation at the beginning of 1997 at SI Geneva, and connected to the network. A variety of tests and trials will then be carried out under operational conditions.

In the initial phase of the **Development of a high-temperature superconductivity cable for energy technology** project [9], the first questions to be dealt with concern the formation and development of cables. Aspects to be studied here include mechanical load capacity, geometry and capacity dependencies of the anticipated electrical and thermal losses, and cooling processes below 77 Kelvin.

Switzerland is still participating in the IEA project, **Assessing the Impacts of High Temperature Superconductivity on the Electric Power Sector** [9]. The experts concerned meet twice a year and summarise the international developments in clearly structured reports. Preparatory work is currently in progress for a workshop on high-temperature superconductivity cables.

A *current limiter* with 1 MW capacity developed by ABB Switzerland on the basis of high-temperature superconductivity material has been installed in the North-East Switzerland Electricity utility (NOK) Löntsch storage power station as the first industrial application in a power plant, 10 years after the discovery of high-temperature superconductivity, and is to be tested in continuous operation. With this current limiter, the development of which has been co-financed by the PSEL, it will be possible to significantly reduce the damage of short circuits.

b) Power electronics

In the Federal Office of Energy project, **Preparation of energy-relevant projects for the implementation of LESIT results** [10], attempts are being made to identify energy-relevant implementation projects in collaboration with LESIT participants and the industry, and - given sufficient commitment and interest on the part of the industry - to accelerate their processing in the form of initial support. Promising criteria were drawn up on the occasion of a one-day meeting held in December 1996.

Uninterruptible power supply systems are used for protecting sensitive and critical electrical equipment. In a project currently in the preparation stage, comparative and traceable quality characteristics of uninterruptible power supply systems are to be identified in collaboration with the industry. The aim is to make it possible for planners and proprietors to carry out evaluations of systems of this type according to quality and energy-relevant criteria.

c) Low-frequency electromagnetic fields

A study carried out at the Paul Scherrer Institute in 1993/94 examined the effects of 50 Hz magnetic fields on the Swiss population, and it was found that the threshold level of 100 µT outside of the workplace set by the Federal Office for the Environment, Forests and Landscapes was not exceeded.

3. National and international co-operation

A summary of the contractually specified costs of all current Federal Office of Energy projects in the field of electricity indicates that the contributions of this Office amount to less than one-third of the project costs. The remaining two-thirds are covered by the industry concerned. This strongly emphasises the degree of commitment on the part of the industry and the level of co-operation that has been achieved. In connection with all these projects it has become apparent that the various industrial partners concerned are willing to participate to a considerable extent and thus offer a significant degree of co-operation.

In addition to the co-operation already referred to elsewhere, Switzerland's participation in the "High-temperature Superconductivity" and "Demand Side Management" programmes of the IEA continues to represent an excellent platform for international collaboration. This has given rise to valuable impulses and information as well as new contacts, especially as a result of the visit by the Programme Director on the occasion of the meeting of the Executive Committee of the IEA High-Temperature Superconductivity programme held at Argonne National Laboratory near Chicago, USA [15].

At present, concrete clarifications and preparations are in progress for active participation in the **Energy Efficient Motors and Drives** project, which has been initiated within the framework of the EU SAVE II programme.

4. Practical implementation, pilot and demonstration projects

a) Power/electric motors

In view of the successful results of the Federal Office of Energy's project, *Small-scale circulation pumps with a high level of efficiency* and the subsequent intensive implementation activities (expert reports, participation in the international conference on pumps held in Karlsruhe in 1996), the industry concerned has decided to commence series development. The focus of attention of the **Field testing of an energy-efficient small-scale circulation pump** pilot and demonstration project [11] is on testing its suitability in practice and obtaining additional findings for further development with an aim to series production. Field tests are being carried out in around 30 locations with the newly developed pilot series. To accompany these tests, activities are also being envisaged with the aim of increasing the degree of acceptance among planners and

operators, and sensitising the heating industry. It has also been possible to initiate corresponding activities in Germany as a result of contacts with the Wupperthaler Institute.

The marketing activities following the OPAL project, *Development of a program system for supporting the energy-optimised, non-manufacturer-related design of electric drive systems*, which was completed at the end of 1995, are being implemented intensively as before. It is especially pleasing to be able to report that, now that an English version has become available, and firm contacts have been established with EU research centres, it has been possible to awaken the interest of the EU. For example, the EU has entrusted the Swiss OPAL developers with the task of producing a light version of this program, which it subsequently intends to distribute throughout Europe. Implementation has also been accelerated as a result of participation at the *best '96* drive mechanisms trade fair in Zurich and the international EU conference on *Energy Efficient Improvements in Electric Motors and Drives* in Lisbon.

Product development in the field of *integral drives* in the low capacity range, which was started at the same time, has already brought in a number of significant framework contracts. The interest shown by a variety of industrial sectors on an international scale is extremely high. Various field tests and product developments in the fields of lifts, cranes, weaving machines, printing machines, ventilators, etc., are now in progress. Implementation is also receiving support as a result of high attendance at international conferences and exhibitions.

b) Office equipment/data processing networks

In the **96.010 power manager** project[12], the existing power management system serving as a functional model for data processing networks has been further developed into a prototype and tested under operating conditions in a number of such networks from a point of view of reliability and user comfort. The first evaluations have been positive.

The international conference on *Energy efficiency in office equipment and consumer electronics* in Stockholm provided an opportunity for presenting the corresponding Swiss activities to an international public of specialists in the field.

c) Demand side management

Many electricity utilities repeatedly face the question of concrete, targeted activities in the field of *demand side management*. Following the completion of the *Identification of the priority activities in the field of demand side management* project, the findings obtained were passed on through intensive implementation efforts. Within the VSE, various information events were organised by the INFEL, and all cantonal and municipal energy authorities are informed about the results of the project within the framework of a reporting conference. In addition, publication on an international scale was achieved as a result of the presentation of a lecture at an important conference in Vienna (DA/DSM).

The results of the IEA demand side management programme have also been published in the specialist press (VSE Bulletin, Infel) in the form of a number of articles. Implementation is assured thanks to the active participation of the industry concerned in the *Communication* sub-project. Finally, extensive lectures have been held on demand side management by the *Energy Analysis Research Group at the Federal Institute of Technology, Zurich*.

d) Miscellaneous

The aim of a project called **Ecological Refrigerators Switzerland** [13] is to develop a refrigerator that is environmentally compatible and recyclable, and which it is hoped will cut present-day energy consumption levels by half thanks to new vacuum insulation technology. However, it is still on hold due to financial difficulties on the part of an industrial partner involved in this project.

In the **Enper energy saving in passenger train carriages** project [14], following a study initiated within the framework of Energy 2000 a Swiss Federal Railways passenger train carriage (type Bpm Z1 20-70) is being systematically renovated as a precursor to the R4 series, detailed problems concerning energy efficiency measures are being clarified and the cost/benefit ratio is being closely examined.

5. Evaluation of 1996 and outlook for 1997

Following its approval in the first half of the year, the 1996/1999 energy research concept was distributed to a large number of interested parties in the form of a direct mailing, and was also announced in a variety of publications. An accompanying letter drew special attention to the fact that the concept was intended to have an initialising effect in the sense of a "bidding paper". The feedback was considerable and generally very positive. At the same time, implementation of the concept was started and the various activities were reinforced according to the defined priorities.

Although various activities have been started, the tasks within the priority field of *data processing networks* have unfortunately not progressed as effectively as planned. The main reasons for this have already been mentioned elsewhere. Nonetheless, it is intended to intensify efforts in this sector in 1997.

The tasks in the priority field of *drives/motors* have progressed satisfactorily from both a qualitative and a quantitative point of view. And the implementation of the obtained research findings in the form of pilot and demonstration projects and commercialisation activities has been progressing pleasingly.

6. List of projects

[1] H.P. Biner (ENGINEERING COLLEGE VALAIS, Sion): **New converter technologies for renewable energy sources based on the example of small-scale hydropower plants.** (FR)

[2] H. Glavitsch, D. Brunner, L. Maiocchi, (FEDERAL INSTITUTE OF TECHNOLOGY, ZURICH) and Th. Arpagaus (AMSTEIN + WALTHERT AG, Zurich): **Load specification model for distribution transformers.** (AR)

[3] J. Nipkow (ARENA, Zurich): **Energy-saving and utilisation potential of new tape core distribution transformers.**

[4] A. Stoev (TECHNOCON AG, Zurich): **0.55 kW - 22 kW integral drive with regenerative energy recuperation.** (AR)

[5] R. Tanner (SEMAFOR AG, Basel): **Feasibility study for the expansion of the OPAL program system with frequency converters.** (FR)

[6] B. Aebischer (FEDERAL INSTITUTE OF TECHNOLOGY, Zurich): **Promotion of efficient energy use in information technology and consumer electronics.** (AR/FR)

[7] D. Haefelin (INFEL, Zurich): **Follow-up project on fields of activity in demand side management; Guidelines for successful marketing.** (AR)

[8] H. Züger (ABB SÉCHERON SA, Geneva): **High-temperature superconductivity transformer.** (AR)

[9] G. Véscey (EPFL, Lausanne): **Development of a high-temperature superconductivity cable for energy technology.** (AR); **Assessing the impacts of high-temperature superconductivity on the electric power sector.** (AR)

[10] H. Späth (UNIVERSITY OF KARLSRUHE, Karlsruhe): **Preparation of energy-relevant implementation projects for LESIT results.**

[11] W. Meyer (BIERI PUMPENBAU AG, Munsingen): **Field testing of an energy-efficient small-scale circulation pump.**

[12] P. Aeschlimann (LINARD AG, Lommis): **96.010 power manager.** (AR)

[13] B. Bosshart (IET, Rorschach): **Ecological refrigerator.** (Interim report)

[14] C. Brunner (CUB, Zurich): **Enper energy-savings in passenger train carriages.**

(AR) 1996 annual report available

(FR) Final report available

7. References

[15] R. Brüniger (R. BRÜNIGER AG, Ottenbach): ***Federal Office of Energy "Electricity" research concept for the period from 1996 to 1999***, dated June 1996. ***Report*** on IEA Executive Committee Meeting at Argonne National Laboratory, May 1996

[16] M. Brunner (FEDERAL OFFICE OF ENERGY, Berne): ***4-year plans, 1996 - 1999 for "Other forms of renewable energy", "Geothermics, small-scale hydropower plants, wind"*** dated July 1996.

[17] IEA demand side management programme: ***Evaluation of communications to meet customer/utility requirements for DSM and related functions***, Final Report, January 1996.