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Research Programme "Electricity"

1997 Report of the Research Programme "Electricity" of the Swiss Federal Office of Energy

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1. Programme priorities and objectives for 1997

The fundamental goal of the „Electricity“ research programme is to contribute towards optimised handling of electrical energy, from its generation and distribution through to its efficient use.

The direction of activities aimed at promoting ***efficient use of electricity*** had to be changed due to the rapid progression of the market liberalisation and deregulation processes, since the field of ***demand-side management***, which had originally been regarded as relevant, has meanwhile lost in importance, or is being replaced to an increasing extent by market-economy mechanisms such as *energy contracting*. This development is also underlined by the fact that the electricity industry has dissolved its demand-side management workgroup. The corresponding activities of the Federal Office of Energy have therefore been successively terminated, and it has transferred its focus to the fields of *energy and information-technology* and *drives/motors.*

In the field of ***energy and information-technology***, the priorities were to establish a broadly-based support group, create a recognised competence centre and initiate new projects.

With respect to ***drives/motors***, in addition to the continuation of the current activities, the main priority was to organise a technological progress seminar in order to implement and distribute the results achieved to date.

In the field of ***high-temperature superconductivity for energy technology***, it was felt that there was a need for a suitable discussion forum between the industry, universities and funding institutions for an efficient exchange of information and for focusing funds on promising projects. So one of the principle goals for 1997 was the creation of an appropriate information hub.

As before, the objectives of research efforts in the field of ***transmission and distribution*** were to provide appropriate support for projects aimed at achieving a high level of network availability and a minimisation of transmission losses.

2. Tasks accomplished and results obtained

GENERATION / PRODUCTION

With respect to the use of ***hydropower*** there are practically no technical problems that would stand in the way of further expansion. Alongside the already known ecological, approval-related and economic aspects, the continuing liberalisation process is tending to have a suppressing effect on investments. The toughening of competition here is also causing the electricity industry to hold back – or even discontinue - certain projects in the field of hydropower.

STORAGE

The storage of energy in various forms is of central importance throughout the energy sector. The „Electricity“ programme focuses on mechanical and electromagnetic/electrostatic storage technology, but does not support any such projects at this time.

In the field of flywheel technology, various activities are currently being carried out on both a national and an international level. An example of the use of this technology within Switzerland is the equipping of trolley buses operated by the public transport services of Basel with flywheel storage devices, with which it is possible to achieve savings of around 300,000 kWh per annum. On an international level, attention is drawn to the example of ***„FlyWiP“*** (Flywheel Energy Storage for Wind Power Generation), which was recently launched within the scope of the European JOULE programme with substantial participation by the Swiss industry, and which - as part of a pilot system - is adopting a network regulator function for decentralised energy producers (wind) using a flywheel storage device.

Finally, reference should also be made to the IEA's „Energy conservation through energy storage“ programme, in which one of the topics being dealt with is „Energy storage technology for utility network optimization“. The question of whether Switzerland should participate in this programme is currently being discussed with the electricity industry.

TRANSMISSION / DISTRIBUTION

Motivated by the changed circumstances in the field of energy supply, and made possible by the availability of high-capacity electronic components, the concept of a quickly adaptable energy transmission system (known as „***F***lexible ***AC T***ransmission ***S***ystem“, or „***FACTS***“) has been introduced. As a result, it is possible to increase the degree of control and exploitation of existing transmission capacities. In a project called „***Development of new system-oriented FACTS elements***“, corresponding network studies with simulations are being carried out while taking account of profitability, in addition to the development and optimisation of FACTS elements and system concepts.

With the aid of suitable modelling - thanks to the already developed „***load determination model for distribution transformers***“ - with a low number of point measurements, it is possible to obtain a fairly precise picture of the load in a distribution network. To do this, use is made of statistical data concerning seasonal fluctuations of various load components. These figures result from a variety of studies and cover the time-invariant basic household curve, boiler and heating loads and the greatly fluctuating seasonal lighting loads. The neuronal network method was applied as a model identification algorithm. A programme tested by the electricity industry is now available, which provides a user-friendly graphic interface on a PC. This application permits a more precise calculation of loads in a distribution network while considerably simplifying operation and planning processes, and it also helps avoid over-dimensioning with low operating efficiency. During the final stage of the project, a specialised company was founded which has a relevant product

range and proven experience in this market segment, and which will take over the marketing tasks and product launch.

In the „***Reduction of losses from network transformers***“ project, a preliminary study was carried out to draw up a systematic list of transformers (2VA up to 1000 MVA), and the estimated losses amounted to around 1.5% of the national consumption. Similarly, a loss-reduction potential of approximately 1/3 was identified as certainly realistic, based on preliminary estimates and taking technological trends into account. Alongside small-scale transformers which are used in a wide variety of applications, significant reductions in losses are possible in the commercial and industrial sectors, as well as in the field of energy distribution, and these are often realised within the bounds of economic efficiency. In an additional feasibility study, „***Electronic distribution transformers***“, it was demonstrated that it is possible to develop electronic distribution transformers with efficiency levels between 98.5% and 99%. Other studies will be setting out to perform more detailed analyses of the situation concerning distribution transformers while taking account of various technological and financial aspects.

Generally speaking, the capacities of decentral generators have been fairly low to date, and thus have not caused any notable network problems. But this is likely to change in the future as the number and capacities of such generators increase. A project called „Reliability of safety switches to prevent island effects“ is to study the resulting problems for networks.

APPLICATION / EFFICIENT USAGE

Power and electric motors

In the „***0.55 – 22 kW integral drive with regenerative energy feedback***“ project, the development of prototypes of a whole series of integrated frequency converter drives was completed for pumps, ventilators and constant instantaneous applications from 0.55 – 22 kW. The various integral drives were tried and tested in around 300 field installations in close collaboration with the industries concerned. In addition to the actual increase in efficiency due to the integration of converters and motors, the acceptance of the application of variable-speed drives has also risen, and this should lead to more widespread application of this energy-efficient technology.

The aim of the „***Expansion of the OPAL program system with frequency converters***“ programme is to place researchers in the position in which they are able to make a selection of motors for variable-speed drives from products from a range of manufacturers, and from a point of view of optimum energy efficiency. The project’s tasks in 1997 consisted in the implementation of a prototype, the preparation of a testing schedule and initial tests on different motors for later comparison with the results of the programme.

A *rapid diagnosis system* developed at the Federal Institute of Technology, Lausanne, makes it possible to conve-

niently and accurately calculate the effectively required capacity of motors for use in ventilation and other systems, as well as determine the most suitable replacement motor on site. This achievement received the 1997 „Prix eta“ award.

Various types of small-scale ventilators (< approx. 2,000 m3/h) are used for widely differing applications. In Switzerland, the corresponding electricity consumption is estimated at approx. 1% of the national figure. A preliminary study is intended to identify the fundamentals for research and development priorities for small-scale ventilators with a high degree of efficiency, as well as to define promising related projects in this field. In the first stage, the uses and installation situations of small-scale ventilators have been analyzed and quantified.

Energy and information technology

As a result of the constant increase in networking and the use of mobile computers, the strict separation of computers and communications, office and home, and even work and leisure-time, is gradually disappearing. In view of the more widespread use of communications and information technology, the topic of Energy and information technology remains a central priority of the research programme.

The „***Energy management in networked electronic systems***“ project shows alternative ways of influencing electricity consumption by sensitising the market, applying more efficient technologies, and introducing appropriate planning plus the consistent use of an energy management system. A number of projects and activities have been identified and steps have been taken to initiate their implementation.

In the „***Energy consumption of network components***“ project, for example, energy measures concerning network components (routers, switches, multiplexers, etc.) have been carried out for the first time on two modern networks involving 82 and 1,200 users respectively. One of the findings obtained from these measurements is that the consumption is constant in terms of time and does not depend on the data flow or network topology; on the other hand, it was also discovered that the measured consumption levels were often less than 30% of those indicated in the product specifications, and this can give rise to an over-dimensioning of infrastructure installations such as air-conditioning plants and uninterruptable power supply systems. Two of the world’s leading manufacturers from the USA were confronted with these findings, and one of them noted them with interest.

In order to have up-to-date figures available, a project called „***Specification of the energy consumption of electronic household appliances, office equipment and automated devices in Switzerland***“ was initiated to record the corresponding data. Similarly, available data has also been collected in a project called „Fundamentals for research activities in the field of PABX (telephone exchanges)“, in order to identify the required research tasks.

As before, the objectives of the „***Competence centre for the promotion of efficient energy use in information technology and consumer electronics***“ are to gather, process and distri-

bute relevant data and know-how. In the year under review, it focused its efforts primarily on the management of the IEA project***, „Internationally co-ordinated procurement of innovative copiers***". The management of this project was handed over to the US environment authorities (EPA) as of October 1997. In addition, a project called „***Energy consumption and energy-savings potentials for automated devices***", was drawn up and prepared for implementation. In the first stage, the various devices to be examined were identified and systematically categorised. At the same time, the data already available was gathered together and presented in a preliminary study. The next step will be to produce an approximate assessment of the energy consumption of these devices. Important types of automated devices will simultaneously be subjected to in-depth analyses, and it is intended that these studies will primarily focus on dispensing machines.

In view of the fact that this office is orienting itself towards electronic data processing networks, it is to operate under a new name as of the beginning of 1998: „*Competence centre for energy and information-technology*".

Demand-side management

Switzerland actively participated in two projects within the scope of the IEA's „Demand-side management" programme. In view of the rapid progress of the market liberalisation and deregulation processes, however, the significance of demand-side management has dropped considerably, and it is being replaced by market-economy mechanisms to an increasing extent. And since the future tasks foreseen for the programme are only of interest to Switzerland to a limited extent, it has now withdrawn from the programme.

The original goal of the follow-up project, „***Priority fields of action in demand-side management: the way towards successful processing of the market***", was to systemise activities associated with demand-side management and identify promising fields of action. But as a result of the opening-up of the market and the accompanying changes, the role of market-related measures has altered. These no longer take the form of voluntary actions, rather they are now become marketing measures. Efficient applications, for example, enhance the competitive capacity of the energy supplier and therefore help the latter gain and maintain its own share of the market. This project took account of this development and focused on the preparation of a corresponding marketing manual for the electricity industry.

INTERDISCIPLINARY PROJECTS

Superconductivity

The goal of the „***High-temperature superconductor transformers***" project consisted in testing this technology in practice producing a prototype-transformer, and convincing proof of its effectiveness was supplied following the installation of the first three-phase high-temperature superconductor transformer

(630 kVA, 18.7 kV) on the network of SI Geneva.

With respect to the „***Development of a high-temperature superconductor cable for energy technology***“, it was possible to take the necessary conceptual decisions (cable construction) on the basis of the studies that had been carried out. Insulation systems and a model cooling circuit were studied on an experimental basis, and safety aspects were examined, as were various cable manufacturing methods.

In the spring, an international congress on high-temperature superconductor cables was organised as part of the IEA's „***Assessing the impacts of high-temperature superconductivity on the electric power sector***“ programme. In addition, a variety of reports were prepared and submitted to interested parties within the sector.

Power electronics

The „***Processing of energy-relevant implementation projects arising from the results of LESIT***“ programme led to the definition of a number of projects. One of these was the already-described FACTS project, and two others – „***Comparison of component concepts for MOS- controlled high-voltage power semiconductor switches with Trench IGBT***“ and „***Analysis and optimisation of IGBT module packages***“ – deal with the energy optimisation of power components.

Uninterruptable power supply systems serve to increase the level of supply security of sensitive and critical electricity-consuming devices. UPS systems differ considerably in terms of quality and efficiency depending on the technology used, and thus cause correspondingly higher or lower energy losses. With the „***Parameter identification and testing procedures for uninterruptable power supply systems***“ project, the identification of parameters and a comparison of quality and energy-relevant data were carried out, and a testing procedure was drawn up in draft form. The latter is to be reviewed in 1998.

Low-frequency electromagnetic fields

According to the latest results of US research, no statistical indicators have been found to substantiate the suspicion that the magnetic fields produced by high-voltage lines can cause leukaemia among children. This means that one of the controversial debates concerning a link between magnetic fields and the development of leukaemia during childhood has been concluded for the time being.

A conference under the heading, „The phenomenon of electro-sensitivity“ was held at the Swiss Federal Institute of Technology in Zurich. The question of the extent to which an identifiable risk group of electro-sensitive people might exist was examined within the scope of the Federal Institute of Technology's „NEMESIS“ research project.

New, innovative project ideas

In the „***Hydraulic isothermal compressor***“ project, in which a new type of compressor is being researched, following an interruption due to sickness a variety of optimisation tasks were carried out on the prototype.

3. National and International Co-operation

For cost reasons, as well as in order to increase the chances of implementation, only those projects are supported which are also characterised by substantial commitment on the part of the industries concerned. In this way, co-operation between universities, colleges of technology and the industrial sector is assured on the domestic front.

As before, Switzerland's active participation in the IEA's „High-temperature superconductivity“ programme represents an excellent platform for international co-operation. The visit of the head of this programme on the occasion of the meeting of the Executive Committee of the IEA's „High-temperature superconductivity“ programme in Milan resulted in valuable impulses and exchanges of information, as well as the establishment of new contacts.

As already stated, Switzerland has discontinued its participation in the IEA's „Demand-side management“ programme, though the contacts already established are to be maintained.

In view of the unattractive conditions and the rather unpromising tasks of the EU's „Energy-efficient motors and drives“ (SAFE II) project, the Federal Office of Energy is not considering participating at this time, but it will be keeping an eye on the various activities and developments.

Switzerland's involvement in the IEA's „Energy storage“ programme in the field of energy storage technologies for utility network optimisation is currently being reviewed together with the electricity industry.

4. Implementation of results, pilot and demonstration projects

Electric motors/Drives

On the basis of the research results obtained in the field of electric motors and drives, a Swiss Federal Office of Energy workshop was held at Technopark at the end of October 1997 involving the Federal Institute of Technology, Zurich and the relevant industries. The event was attended by over 60 participants, and talks by high-level lecturers revealed a great deal of new information plus details concerning current trends. The conference documentation that was drawn up provides a broad overview of the relevant national and international activities.

Although considerable delays arose in the „***Field-testing of an energy-efficient small-scale circulation pump***“ pilot and demonstration project, the planned field tests should now go ahead without further delay. These involve 20 existing prototypes at a number of different locations.

The implementation of the „***Integral drives***“ project has brought pleasing results: thanks to the successful development efforts and the high degree of interest shown by the industrial sector it has been possible to create 8 new jobs in Switzerland following the establishment of a new company there. In order to carry out world-wide marketing, alongside participation at a number of trade fairs (e.g. Hanover 1997), two new companies have also been established in Germany and the USA. Intensive co-operation aimed at implementation in industrial applications has developed among a dozen or so companies in a wide range of industrial sectors: printing and textile machines, ventilators, elevator drives, pumps and compressors are just a handful of examples of the broad areas of application of integral drives.

Within the scope of the IEA's „Demand-side management“ programme, a pilot project has been put out to tender concerning a high-efficiency motor (capacity range, 0.18 – 110 kW). The aim is to give the industry the incentive to manufacture efficient drives, as well as provide it with corresponding marketing support.

OFFICE EQUIPMENT / DATA PROCESSING NETWORKS

The extensive information work carried out to date has been continued in the form of a brochure entitled „Energy-efficiency in networks – made simple“, which takes the examples of two different pilot projects to describe how servers can be powered down at night and during weekends by remote control and without any notable restrictions for users.

In the „Energy manager type 96.010“ project, the energy management system which served as a function model for data processing networks was further developed into a prototype and subsequently tested from the points of view of reliability and user-friendliness. Positive results were recorded with respect to system reliability, but the study indicated that there was still a great deal of reticence on the part of operators, who are afraid of system interruptions occurring as a result of its use. As a consequence of these findings, new marketing strategies are now being examined.

Preparations have been made in close collaboration with the manufacturing and operating industries to carry out studies relating to energy-efficient automatic teller machines. The specifications are now available and the corresponding pilot projects will be prepared in spring 1998.

A support group for energy management in networked systems was established in 1997. It comprises representatives from user groups, university researchers, the information technology industry as supplier, and the federal government. Meetings are held every six months with the aim of securing an exchange of information with respect to practical application.

An AC network manager has been put into operation in the new Federal Office of Energy building in the form of a pilot

installation, and it controls the switching on and off of central components according to time and requirement criteria. The fact that the AC manager is linked to staff identity cards means that, in the evenings and at weekends, only those servers or components are started up to which the person concerned has the necessary access authorisation.

MISCELLANEOUS

With the „Energy efficiency in passenger trains“ project, it was established on the example of a passenger carriage that its energy consumption could be cut by more than fifty percent. It is planned that Swiss Federal Railways will implement the proposed measures on the occasion of the next overall service of its passenger carriages.

In the „Ecological refrigerators“ project, 10 prototypes have now been produced, and tests, optimisation work and marketing activities have been planned for 1998.

5. Summary for 1997 and outlook for 1998

In the main area of focus - *energy and information-technology* - broad-ranging activities have already been initiated. The echo from both the industrial sector and major network operators is encouraging, and indicates that there is clearly a call for further action. The user group that was established proved to be an extremely effective forum for the exchange of information. However, the still existing latent fear of system interruptions shared by operators remains a problem factor, and this aspect also needs to be given high priority in the future.

The tasks carried out in the field of *drives/motors* have progressed satisfactorily, in terms of both quality and quantity. And the implementation of the results of research in the form of the workshop that was organised, and through the commercialisation efforts concerning integral drives, can also be assessed as positive. The goal in 1998 is to expand activities in this area through additional system-oriented drive projects.

In order to make the research activities carried out in the field of *transmission/distribution more widely known, it is planned* to conduct a concentrated know-how transfer in 1998 in the form of a seminar to be organised by the Federal Office of Energy.

Following the installation in Switzerland in 1996 of a current limiter on the network as the world’s first *high-temperature superconductor* device, Switzerland has again adopted a leading position in this field with its three-phase high-temperature superconductor transformer, and now aims to maintain this position over the longer term.