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Research Programme "Electricity"

1995 Report of the Research Programme "Electricity" of the Swiss Federal Office of Energy

Head of Programme

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1. Programme Summary and Objectives for 1995

The "Electricity" research programme encompasses activities for the optimised use of electrical energy from its generation through to its distribution, and on to its efficient application. The fundamental objectives of the programme are a protective increase in production, the optimisation or improvement of the degrees of efficiency in the fields of storage and transmission, as well as an efficient use of electricity in a wide variety of areas of application. In 1995, the preparation of a research concept for the period from 1996 to 1999 was also an integral part of the programme. This is based on progress achieved to date on the one hand, and on the other hand on the general energy research concept elaborated by the Swiss Federal Energy Research Commission and approved by the Swiss Federal Government. In view of the strained federal finances in particular, the fact that the federal Office of Energy can only function in a subsidiary capacity was emphasised more strongly in the 1996 - 1999 concept. Although the direction to be taken and the specified priorities have been clearly defined in the concept, its implementation will only receive financial assistance from the Federal Office of Energy to a limited extent. In practically all cases, considerable contributions from third parties or industrial partners will be required.

Since various inquiries and studies were carried out simultaneously for defining the medium-term concept, the preparation of the concept largely correlates with the research themes worked on in 1995. The following activities should be mentioned in particular here:

- Clear priorities were defined on the basis of international research activities in the field of "transmission and distribution", and these were passed on to the two Swiss Federal Institutes of Technology and the industry.

- A variety of implementation activities were carried out in the field of "high-temperature superconductor technology". The Federal Office of Energy's defined strategy was notified to various groups of researchers in industry and the universities, and to the director of National Research Programme 30 (basic research on high-temperature superconductor technology). This gave rise to the fact that, in addition to the superconductor transformer project currently in progress, detailed discussions are now being held concerning the launching of a new high-temperature superconductor energy cable project.

- In the field of efficient energy use, a great deal of attention was focused on energy management in data processing networks. Preparatory tasks in this field have shown the potential and possible directions to be taken for the next three years. Also, the research activities in the field of "demand-side management" throughout Switzerland were co-ordinated more intensively.

- The implementation of the Federal Office of Energy's "integral motor" workshop introduced at the end of 1994 was intensified, and as a result it was possible to

find an industrial partner for the development of a prototype of a completely new type of integral motor.

2. Tasks Accomplished and Results Obtained

GENERATION / PRODUCTION

The field of "hydropower" is not one of the programme's priorities. On the one hand, the electricity sector and the industry finance a major portion of the research work, which is mainly focused on large-scale power plants. And on the other hand, in the field of small-scale hydropower plants in particular, the promotion and support of these installations is being actively encouraged, primarily through the PACER[1] (1990-1995) and DIANE[1] (1992-1997) programmes. Small-scale hydropower plant technology is in fact being supported in a variety of pilot and demonstration programmes, as well as by promotion contributions from the federal government and the cantons. In the field of small-scale hydropower plants, a study on the ***"Energy balance of small-scale hydropower plants"*** was requested within the DIANE Programme in order to substantiate the ecological advantages with factual data. In this study, the yield factors (the balance between generated and used energy for the construction of a power plant) and the energy return period (the period of operation until the energy used for construction of a power plant has been generated) were determined for small-scale hydropower plants on the basis of actual examples. In every case it can be clearly seen that, with yield factors of between 87 and 583, and with energy return periods of between 0.08 and 1.4 years, small-scale hydropower plants are able to make a valuable and ecological contribution to energy production.

In the ***"New converter technologies for renewable energy sources as shown by the example of small-scale hydropower plants"*** project, the new converter was successfully constructed and installed in a 50 kW drinking-water power plant (replacement of pressure reduction valve in the drinking-water supply) in co-operation with the industrial service of the City of Sion. However, the generator - which had been constructed by the Engineering College of the Canton of Valais - presented major problems at higher revolutions, which meant that a second machine had to be developed. During testing of the second machine, and as a result of modifications carried out in the drinking-water network, certain problems arose with regard to control. These have since been overcome, however, and the plant has been functioning faultlessly since the beginning of December 1995. The various measurements of efficiency levels have been carried out from this point onwards, and the results, as well as the completion of the project, are expected at the beginning of 1996.

[1] National Promotion Programmes

With the ***"Experimental research centre for the rehabilitation of small-scale hydraulics, Montcherand Laboratory"***, a new centre for the experimental study of small-scale water turbines is currently being established. Its construction and installation are now in progress, and it is expected to be completed by the autumn of 1996.

STORAGE

The storage of energy in various forms is a matter of central importance in the energy sector. The present programme focuses on mechanical and electromagnetic/electrostatic storage technologies. Other storage technologies are the topics of additional Federal research programmes.

The goal of the ***"Cyclical lead accumulator charger"*** project, which was terminated at the end of the year, consisted in developing a new charging procedure, with which more energy per kilogram of lead can be stored, whilst increasing the service life and shortening the charging time thanks to a more protective charge. Extensive tests have indicated that the various types of batteries react differently. For example, a traction battery is more suitable for this new procedure than a UPS battery. But it is not yet possible to make any definitive conclusions regarding the ideal charging method for all battery types. It is intended to expand the tests on the basis of the available measurement data to such an extent that it will be possible to clearly determine whether different battery types can be charged with one and the same set of parameters, and thus ultimately to develop a universal charging device. The results obtained will be transferred to the Federal Office of Energy's "Fuel cells and batteries" programme, since here the subject of "intelligent battery management" is being studied in full.

TRANSMISSION / DISTRIBUTION

The declared objectives in the field of transmission/distribution are to attain, respectively retain, the high network disposability, coupled with a maximum network quality and a minimisation of transport losses. The priority for the next few years consists in dealing with problems in the distribution network.

The goal of the ***"Load determination model for distribution transformers"*** project is to obtain a picture of the distribution network through modelling and with few measurements on location. The findings obtained about the network will considerably simplify operation and planning procedures, and it will also be possible to avoid over-dimensioning with a low degree of efficiency. The model chosen as the solution is based on transient measurements and suitable simulations which utilise statistical knowledge concerning seasonal changes of the various load components. The existing model has been successively refined, and it has been possible to implement distinct pattern recognition algorithms ("neuro fuzzies"). Parallel to this activity, work has also commenced on the development of a user-friendly application surface.

The ***"NIS/DMP - a network information system for documentation, monitoring and planning of electrical distribution networks"*** project expands a conventional network information system (NIS) from a purely documentation tool into an efficient planning one. The aim of this project was to prepare a prototype on the one hand, with which the solution model for the NIS/DMP was identified and presented for discussion, and on the other hand to prepare the modelling and the implementation of tests and simulations for the characterisation of consumer loads. All the objectives of the project were achieved, and it was brought to a successful conclusion when it was presented on the occasion of a utility seminar. The next step to be taken is to turn the system into a commercial product in co-operation with a number of NIS system companies and with one or more electricity works.

APPLICATION / EFFICIENT USAGE

a) Power and Electric Motors

As a result of the Integral Motor workshop initiated by the Federal Office of Energy, a company specialising in this field expressed its interest in a corresponding research project. A project called ***"Integral drive 0.55 kW - 22 kW with regenerative energy feedback"*** was subsequently launched at the beginning of the year. The aim of the project was to provide evidence for a maximum integration density with a low utilisation of material and a high degree of functionality, through the development of a prototype. The first prototype was developed in the capacity range of 3.5 kW with 400 V. According to the current status of technology, this prototype represented the most highly-integrated air-cooled integral motor over 0.5 kW and 400 V. Thanks to its compact construction, the distinguishing feature of which is a motor extension of only 10 cm, and its flexible control, it can be assumed that this energy-efficient drive will be put into increased application. In 1996, a prototype with a capacity of 12 kW is to be developed.

With the project, ***"Development of a programme system for the support of energy-optimised electric drive systems with multi-manufacturer involvement"***, which was terminated at the end of 1995, a commercial application has been made available which makes an energy-optimised motor design possible in the capacity range of 0.12 to 200 kW. The project succeeded in achieving its declared objective of using a selection procedure involving a number of manufacturers, for at present there are products from 13 engine manufacturers in the software database. Its commercialisation has been in preparation for some time parallel to the project, and now that the software has been completed, a variety of marketing measures are currently being implemented. Contacts for marketing in the EU have also been established. At the moment, this programme cannot include the influence of frequency converters. But since this is something that various users and suppliers consider to be a necessity, the next step is to take the form of a feasibility study to find out to what extent an expansion of the programme is possible in this respect.

The results of the ***"Small circulation pumps with a high level of efficiency"*** project, which was concluded at the end of 1994, were demonstrated to the public in form of a television report and on the occasion of the Ineltec 95 trade fair. After some hesitation, the industry has now decided to develop the functional model with a three-times-higher efficiency for series production.

The majority of locomotives in Switzerland are equipped with electricity recuperation brakes, which permit the feedback of energy into the catenary network during braking for deceleration and downhill travel. The extent to which a more intensive utilisation of recuperation is possible was studied in the ***"Increased utilisation of recuperation brakes in RE 6/6 locomotives of the Swiss Federal Railways (SBB)"*** project, which has now been completed. In addition to a modification of operation during lengthy downhill stretches, this should also be possible by increasing the maximum brake current. Various measurements, together with predictions based on these, indicated that around 100'00 kWh more per year and locomotive can be recuperated than has been the case to date. This corresponds to around 2.2 % of the total annual consumption of the locomotives.

b) Office Equipment / Data Processing Networks

The national and international transfer of research results and the maintenance of contacts remain the principal concerns in the ***"Promotion of efficient energy use in information technology and consumer electronics"*** project. The most significant activities were the organisation of the IEA experts' meeting, "Co-operative Procurement of Innovative Technologies" held in spring 1995 in Zurich, with its supplementary conference on "Market-Pull Activities in Switzerland". The results are summarised in a professional "Market-Pull Report". After the conference, the specialist office was entrusted with the task of studying the copiers sector in detail within the framework of the IEA-DSM procurement activities.

In the 1996 - 1999 research concept, the subject of "energy management in data processing networks" represents a clear priority. In the course of the year, therefore, intensive discussions were held with representatives of the relevant industries and international organisations. The subject is relatively difficult to approach, especially since the industry is still rather reticent despite its declaration of interest. In view of these circumstances, efforts are being made to draw greater attention to this question, and to sensitize both the general public and relevant institutions to it. In order to obtain additional data for this purpose, the presumed savings potential in data processing networks was estimated in the ***"Background tasks for research activities in the field of network energy management"*** project. The results of the study indicated a total consumption by computers and computer networks of around 770 GWh, or 1.6 % of the Swiss electricity consumption. The savings potential through optimised network energy management (purposively switching off central devices and systems outside of utilisation times) is estimated at approximately 222 GWh, or around 29 % of the consumption in this respect. This estimated potential demonstrates that appropriate activities in this

field are certainly worthwhile. As a specific small-scale project, a prototype energy management system was developed for a Novell network. This system ensures that all central network components (server, hub, DAT tape, CD) are switched off at night and during the weekend when not in use. After initial difficulties, the system has now been functioning faultlessly since the end of November 1995. The energy measurements are still in progress, but savings of over 50 % can be anticipated, which are equivalent to approximately 280 kWh per year for the installed network.

c) Metering

The ***"Methodology of electricity savings analysis"*** project was considerably delayed as a result of the efforts to coordinate it with SIA recommendations 380/4. In addition, initial project results have shown that it is not possible to implement the „day-cycle method" as originally foreseen. Since these circumstances meant that the project was forced to pursue a course which is already being taken by private industry with similar activities, it was subsequently abandoned.

d) Demand Side Management (DSM)

Switzerland is participating in two projects within the "Demand Side Management" programme of the IEA: "Development of Improved Methods for Integrating Demand-Side Options into Resource Planning" and "Communications Technologies for Demand Side Management". First results are available in the corresponding reports in addition to the annual reports. In spring 1995, Switzerland was host country for the Executive Committee meeting of this IEA programme, which is held every six months. The chosen location was the "energy town" of Schaffhausen. In order to bring these IEA activities to the attention of a broader Swiss public, a half-day "Joint Swiss/IEA DSM Programme meeting" was organised in addition to the above-mentioned conference. Over 50 participants attended this meeting, at which they were able to obtain details regarding the various activities involved, and actively participate in a lively exchange of information. Reports on this meeting were also published in various journals.

The ***"Determination of priority action fields in DSM"*** project demonstrates a systematic method and range of market-economy tools for identifying and evaluating possible priority action fields. The intention is to enable small and medium-sized utilities to carry out specific demand side activities in potential markets. Now that the methodology has been worked out, the next step is a follow-up project in which it is to be tested with four or so electricity works, and subsequently refined as far as necessary. The results will only be passed on to a wider public after this project has been completed.

The electricity sector has recently founded a Swiss DSM Commission which purposively supports the practical implementation of corporate DSM activities of Swiss electric utilities.

INTERDISCIPLINARY PROJECTS

a) Superconductivity

Within the framework of the present research programme, it is intended to secure the continuity of energy-relevant tasks of the national "High-temperature superconductivity" research programme, which is nearing completion. In the ***"High-temperature superconductor transformers"*** project, a 630 kVA high-temperature superconductor is being developed and connected to the network for one year for a variety of tests. In the initial stage, the feasibility of the transformer concept has been demonstrated on the basis of electrical tests on model coils. The problem of switch-on pre-magnetisation has been solved at the EPFL and demonstrated on a conventional transformer. The next step is to construct a first transformer phase and submit it to mechanical and electrical tests.

Preparatory tasks are currently being carried out with regard to a project concerning a "High-temperature superconductor cable for energy technology".

Finally, Switzerland is still participating in the ***"Assessing the impacts of high-temperature superconductivity on the electric power sector"*** project, which has been extended for further three years. The tasks concerned provide an up-to-date survey of current and foreseeable developments in this field. For example, an international workshop on current limiters (HTS Fault Current Limiters) was organised in Israel within the framework of this IEA programme. Here a Swiss project was presented in which a three-phase current limiter with a rated output of 1 MVA was developed and tested on the network for suitability.

b) Power Electronics

The national power electronic programme „LESIT" was concluded at the end of 1995. According to the concurrent statements of LESIT participants, the results achieved are technologically extremely pleasing. But a follow-up assessment of the energetical importance of the LESIT technologies has concluded that the energetical impacts have to be regarded as relatively low. Although this study has been concentrated on only a handful of case examples, it nonetheless indicates a requirement for action with regard to the energy-related implementation of the developed LESIT technologies. Over the next few years it will therefore be necessary to clarify to what extent LESIT-related implementation projects are to be initiated and supported.

c) Low-frequency electromagnetic fields

At an information meeting held at the Federal Institute of Technology (ETH) in Zurich in December 1995, a report was presented on the COST 244 programme, in which re-

search in the field of biomedical effects of electromagnetic fields is being co-ordinated throughout Europe.

In the USA, this question is not only the subject of widespread discussion, it has also already led to numerous court cases. At a conference held in autumn 1995 under the title of "Electrical smog - its significance from a point of view of environmental law", the Association for Environmental Law provided detailed information on the legal bases in various countries, and described the ordinance that is currently in preparation in Switzerland. The basis of this planned ordinance is the report of the Federal Office of Forests, Landscapes and Environment: "Biological Impacts of Electromagnetic Fields, parts 1 and 2".

d) New, innovative project ideas

It has not been possible to complete the ***"Hydraulic isothermal compressor"*** project, in which a new type of compressor is being researched, due the state of health of the person handling the project. Since detailed tests on the prototype still have to be carried out, it is not possible to make any concluding statements at this time regarding the probable improvement in efficiency.

3. National and international co-operation

As before, the formation of interdisciplinary project teams for all major projects, comprising representatives from industry and universities, is of very great importance, for this strengthens the links between academic and industrial circles, and ensures a more intensive integration of technical colleges. For example, the "Integral Drives" project brought together the Federal Institute of Technology, Zurich, the Engineering College, Sion and a number of industrial sectors.

Through Switzerland's participation in various IEA programmes, international co-operation is taking place in the fields of high-temperature superconductivity and demand side management in particular. And an international orientation is also apparent within the scope of energy management in data processing networks. This is almost unavoidable for the latter, firstly because Switzerland does not have its own industry in this field, and secondly because it only has a comparatively small market.

Within the framework of the preparation of the 1996 - 1999 concept, a large number of specialist discussions and talks were held with relevant - for the most part domestic - industries and universities, thus establishing corresponding contacts. Through the participation of the programme director in the "New Electricity 21" conference held in Paris in May 1995, and in the European DA/DSM 95 (Distribution Automation/Demand Side Management" conference in November 1995 in Rome, it was also possible to gain valuable impulses and establish new contacts for future research activities.

For larger-scale projects in particular, efforts are being made to bring about a greater degree of joint financing through the Federal Office of Energy and the Utility Funding Society PSEL.

4. Implementation of results

In general, in each project the necessary implementation tasks are initiated in good time before its completion. Due to the fact that a number of projects recently reached completion, 1995 proved to be very much characterised by implementation activities. For example, following intensive preparatory work a lengthy report was broadcast in the television programme, "Menschen-Technik-Wissenschaft" ("People, Technology, Science"). Here, four specific projects from the "Electricity" research programme were presented to a wide public. In addition, the trial model of a small circulation pump with a three-times-higher efficiency was demonstrated at the RAVEL stand at the 1995 Ineltec. As already mentioned, the industry undertook to develop the small circulation pump into a series product.

5. Pilot & Demonstration projects

The project to develop an energy-efficient "Bancomat" automatic teller, which was originally initiated by the Federal Office of Energy in collaboration with a Swiss big bank, was adopted in its entirety by the industry and is to be brought up to series production stage on an independent basis in 1996. Here the original stand-by consumption level of between 300 and 400 watts is to be reduced to approx. 25 watts.

In the "Swiss Ecological Refrigerator" project, the goal is to develop a low-consumption, recyclable refrigerator, which will reduce the present-day energy consumption levels by half thanks to a new type of vacuum insulation. Due to financial difficulties on the part of one of the industrial partners, however, this project cannot be continued at this time.

6. Summary for 1995 and perspectives for 1996

1995 was very much marked by the preparation of the 1996 - 1999 concept. In addition to the specialist handling of individual themes, the task of setting priorities was attributed particular importance. These were identified, without losing the necessary flexibility for unconventional and innovative ideas, and concern the fields of distribution, efficient energy use including demand side management, integral motors and energy in data processing networks, as well as high-temperature superconductivity.

As already mentioned, intensive implementation work was also carried out. In addition to the Ineltec presentation of the small circulation pump, the broadcast of the "MTW"

television report was certainly one of the highlights of the "Electricity" programme. The majority of the objectives of the individual projects - technical and qualitative goals as well as deadlines - were met, and attention has already been drawn to the delays arising in certain projects.

In the course of the year, the amounts invested in research and development by Swiss private industry were specified. Throughout Switzerland, the industrial sector invested between 600 and 700 million Swiss francs in the field of "electricity" in 1994. The state contribution of around 18 million Swiss francs mainly comprised Federal Institute of Technology Council funds, and these were primarily used for basic research activities. The sum of around 1.25 million Swiss francs available with the current programme represents a modest proportion. It is precisely for this reason that, in future, the desired control effect has to be achieved by means of purposive support in the form of subsidies.

In 1996, the presentation of the research concept 1996 - 1999 to the Swiss Energy Commission and the subsequent implementation of details will be in the foreground. The approved concept is to be passed on to a large number of interested parties. The intention is that it should have an "initiating" effect among the various research centres in the sense of a "bidding paper".