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Fuel Cells in Switzerland – A Brief Retrospective View

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Abstract: Starting with the work of C.F. Schönbein, Switzerland has made important contributions to the history of fuel cell research. Starting with early developments in the first half of the 20th century, some highlights are mentioned in this article. After a first wave of industrial interest in the 1960s, R&D in SOFC technology started about 1990 and is now on the road towards commercial introduction since about 2000. In parallel, polymer electrolyte fuel cell research has advanced at research institutions, including work on components, stacks, and complete systems.

Keywords: Fuel cells · History · Polymer electrolyte fuel cells · Solid oxide fuel cells

Switzerland has a long tradition in conventional (thermal) power conversion and storage. Only recently, with the involvement of Sulzer Hexis Corp. to develop solid oxide fuel cell (SOFC) systems for stationary small-scale co-generation in family houses, an industrial commitment to electrochemical power conversion has been realized. Unfortunately, one has to state that fuel cell technologies and their possible products have not attracted great interest from Swiss industry up to now.

In contrast, fuel cell science in Swiss academia reaches far back in history. Already at the dawn of fuel cell science, as Bossel convincingly has reported [1], the *fuel cell effect* was discovered by Christian Friedrich Schönbein in 1839. Briefly after this discovery, the invention of a *fuel cell* was described by Grove. Schönbein, born in Germany, was Professor of Physics and Chemistry at the University of Basel at that time.

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Another Swiss contribution to fuel cell science must be mentioned. Emil Baur, a former professor at the Technical University in Braunschweig, became a Professor at the Physikalisch-Chemisches Laboratorium of ETH Zürich in 1911. In many contributions, roughly between the years 1920 and 1940, Baur and his co-workers described results concerning electrochemical power conversion, among other the invention of a high-temperature fuel cell with a solid oxide electrolyte of the zirconium type (1937) [2].

A highly important contribution to the understanding and development of gas diffusion electrodes was made by Alfred Schmid, born in Alsace, later a Professor of Physical Chemistry at the University of Basel [3].

Activities in fuel cell research were taken up again after World War II in Switzerland, in particular in the 1960s at the Brown Boveri Laboratories in Baden. The development of a methanol-fuelled fuel cell led, among others, to a 20 W demonstration unit to power a television station above Visp, Wallis. In the 1960 and 1970s research in the SOFC area was conducted at Battelle Institute Geneva and continued at CSEM, Neuchatel [4].

A revival of fuel cell research in Switzerland started in the late 1980s, with the support of *Bundesamt für Energiewirtschaft* (BEW), Bern, today named *Bundesamt für Energie* (BFE), Bern. Around 1988 an internal BFE-action began, including the first approach to Westinghouse to install a 20 kW demo SOFC in Switzerland. There were several small committee meetings to evaluate these ideas; instead the decision was made to use resources to promote an indigenous Swiss activity, while taking the maximum benefit from international cooperation to acquire knowledge and experience.

In a workshop at Charmey/FR, held 2–6 July 1989, it was concluded that it would more appropriate to initiate research and development in the area of SOFC in Switzerland. At the very same time, the International Energy Agency initiated various annexes on collaborative research and development in the area of fuel cells. At the end of the Charmey workshop a document was drawn up which listed the possible Swiss SOFC areas of interest to collaborate within the IEA network [5]. Most of the major players still active in SOFC R&D in Switzerland today were already present at that meeting (R. Diethelm, Sulzer Hexis; L. Gauckler, ETHZ; A. McEvoy, EPFL; U. Bossel, European Fuel Cell Forum; others).

During the following years, around the Sulzer-Innotec AG activity to develop SOFC technology for co-generation in family houses, and with the strong support of the BFE, a 'CH-network' of different research groups in the area of SOFC was formed (EPFL, ETHZ, EMPA, SIG, SIL, others) [6][7]. Several of these groups have gained good reputations within the respective international scientific community. Recently, based on recent SOFC activities at EPFL-LENI, the company HTCeramix SA was formed, which develops SOFC technology in the sub-kW range [8].

During that time international networking was high on the agenda, in particular within the International Energy Agency. A. McEvoy (EPFL) became Operating Agent

of the Annex 11 of the IEA-Implementing Agreement, SOFC research (1990–1992). Several international topical meetings were organized, among others one on 'Solid Oxide Fuel Cells – Materials and Mechanisms' [9].

Starting 2001, Sulzer Hexis AG has delivered and tested a pre-series of more than 100 units, 1 kW_{el}, 2.5 $kW_{thermal}$, in the field all over Europe. The next system generation will be delivered in 2005 [10].

Around 1990, based on know-how of the Membrel Process (solid polymer water electrolysis), which had been developed at the BBC Research Center Baden-Dättwil during the late 70s and 80s, a project on the polymer electrolyte fuel cell was started at the Paul Scherrer Institut. Participation in the first PEFC-Annex'Collaborative Research & Development on the Polymer Electrolyte Fuel Cell' (1993–1995) helped the project off the ground. In this IEA context, two workshops were organized by PSI, addressing the fuel processing issue for PEFCs [11][12].

Due to the support provided by BFE/BEW and also to the integration into European Projects (partners: Siemens, ECN), a broad basis of materials-, operations- and design know-how for PEFCs could be developed. Collaborations within Switzerland concerned the HTLs of Grenchen/SO, Muttenz/BL, Biel/BE, and Winterthur/ZH, later on also ETHZ. Several 'products' could be demonstrated during recent years, ranging from 100 W H_2/O_2, 300 W H_2/air, 1.5 kW H_2/air portable systems, up to 2.5 kW, several 8.5 kW, and a *ca*. 30 kW stack for mobile applications (boats, respectively cars). Most recently, in collaboration with the company CDM (Construction et Dévelopment Michelin, Givisiez/FR) a concept car, based on the hybrid concept of combining a fuel cell and a super capacitor, was successfully demonstrated 'on the road' [13].

This CHIMIA issue summarizes current activities of fuel cell R&D in Switzerland. Since the revival in 1988, great progress has been made in both low temperature PEFC and high temperature SOFC. Demonstration units as well as pre-series have been tested 'in real environments'. This success of fundamental and pre-commercial research would not have been possible without the support from public sources, in particular without the support of BEW.

New aspects of R&D, like (i) modeling materials, components, cells, and systems [14], (ii) *in situ* diagnostics, (iii) hybrid concepts, (iv) others, have been introduced by various colleagues. Several tens of PhD theses related to fuel cells were accomplished during the past years and many are currently pursued. Fuel cell research in Switzerland is a lively undertaking, held in high esteem by the international fuel cell community. It is desirable to create more industrial activities in the future. The necessary know-how as well as motivated people are available!

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