The Future is Now: Fuel Cell Technology Made in Germany

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The Future is Now: Fuel Cell Technology Made in Germany

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Summary

Fuel cell technology is at a crucial point of its development: the advantages of the technology fit perfectly the energy challenges the world faces today and there is a furious competition between countries to develop national capabilities to produce fuel cells. Governments are moving from R&D support programs to market development programs, so that their protégés benefit from scale effects, an accelerated learning curve and means to bridge the gap with competing technologies. The Fuel Cell Working Group of the VDMA is a key player in this process as it promotes the efforts made by the numerous German players in this field. In particular, it is instrumental in making sure that the German support programs are at par with those of the two other main innovators for fuel cells: USA and Japan.

1 The Fuel Cells Working Group of the VDMA

The Fuel Cells Working Group of the German Engineering Federation (VDMA) is an industry network of fuel cell manufacturers. This working group offers the unique opportunity to jointly address the main issues of the industry as well as to define a common approach for the efficient roll-out of the technology. Its key activities are:

- Networking and sharing on business opportunities
- Systems and components optimization
- Lobbying
- Definition of market launch strategies
- Coordination of industry initiatives
- Public relationship

2 Our Goal: Tackling the Forthcoming Energy Challenge

Our societies have become extremely reliant on energy and electricity in particular. Electricity is present in every aspect of our lives, from our basic needs (e.g. lighting, refrigeration, transportation) to our more elaborate ones (TV, music etc.). This reliance on electricity has grown tremendously in developed countries through the broadening of its applications. It is poised to grow even further with the accelerating emergence of developing countries, especially China and India. Overall, it is estimated that the demand for power will grow by 50% by 2030 with India and China accounting for half of this growth.

Today, electricity is mostly generated from fossil fuels with poor efficiency. This growth in demand will therefore generate tremendous amounts of CO_2, among other pollutants.

Traditional technologies cannot be the solution to tackle this issue:

- Fossil fuels are by nature finite in quantities; supply and prices are volatile
- A few countries control the supply of fossil fuels, most are hit by the “oil curse”
- Current technologies are heavily polluting, as illustrated by the coal plants in use in China and elsewhere

Renewable energies like wind and solar cannot solve the matter either as they are dependent on the weather conditions. As a result, they need to be coupled with storage technology to provide reliability. Those storage systems are currently both expensive and use a lot of space (lakes, dams, puffers etc.).

This situation requires radical change towards clean and efficient technologies; it is the engineering industry’s responsibility to develop those. Fuel cells can address part of the challenge.

3 The Promising Technology of Fuel Cells and its Development

3.1 Fuel cell industry in Germany

There are numerous players in the field in Germany, and they are working hard to make their innovative solutions ready for market applications. Within the VDMA Fuel Cell Working Group, 200 manufacturers of fuel cells systems or components are represented. Small companies account for 50% of those, while large corporations make up the rest (refer to appendix 1 for an indicative list).

Furthermore, over 60 research institutes are involved; most are highly specialized and part of a university. Together, those players represent a tremendous potential for innovation and a deep commitment to making fuel cells a success.

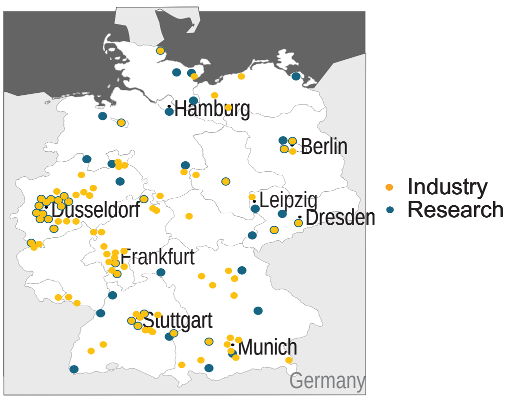

Figure 1: Locations of fuel cells players in Germany [1].

This potential and this commitment materialize in the amount of patents filed[2] and in the split of the 125 MW installed capacity of stationary applications of fuel cells. Both demonstrate that Germany is one of the leaders in the field[3].

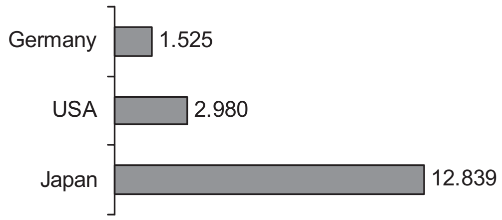

Figure 2: Number of patent filings (top 3 countries 2001 - 2005).

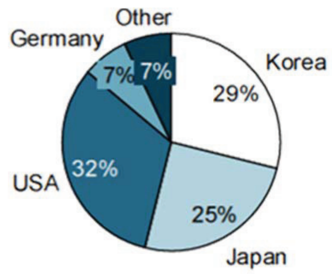

Figure 3: Share of installed capacity for stationary applications per country.

From an application standpoint, fuel cells can be split into three main categories, all of them addressed by German players:

- Special applications with a capacity ranging between 10 W and 15 MW. Those run on hydrogen or methanol and typically consist of small power generation in remote areas or in mobile uses (camping, lighting etc.)
- Stationary applications with capacities from 1-5 kW to 200 kW and above running on natural gas or biogas. They are used to produce power and heat for houses, buildings, plants, large ships etc.
- Mobile applications above 30 MW running on hydrogen. Those consist of cars, buses and trucks powering.

3.2 Technical features of fuel cells

3.2.1 Chemical principle

The basic reaction happening in a fuel cell is the reformation of water from hydrogen and oxygen:

$$2\ H_2 + O_2 \rightarrow H_2O$$

Some fuel cells run on hydrogen, which needs to be generated by an outside process, some run on gas containing CH_4. In the latter case, hydrogen is generated through an internal reformation:

$$CH_4 + 2\ H_2O \rightarrow CO_2 + 4\ H_2$$

Gas containing methane vary in origins but have all great potential. Natural gas and methanol are readily available and their supply is growing. Biogas and sewage gas are also already produced and their use is being developed.

3.2.2 A step change in efficiency and emissions

Fuel cells introduce a step change in the efficiency to turn fuels into power. The electrical efficiency of a fuel cell in the 300 kW class is comparable with a modern 600 MW gas turbine power plant coupled with additional steam turbine. This sophisticated energy solution generates new opportunities inside cities as it fits the decentralized need for heating and cooling.

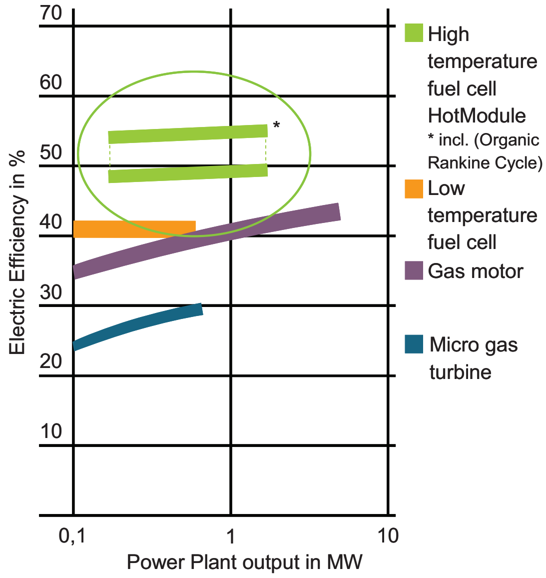

Figure 4: Comparison of the electrical efficiency of MTU's HotModule 346 kW fuel cell and conventional technologies.

As a result of this higher electrical efficiency and of the systematic coupling of fuel cells with Combined Heat and Power systems (CHP), the total efficiency (electrical and thermal) can be as high as 90%. Hence, the CO_2 footprint is dramatically smaller than the ones of all standard power producers.

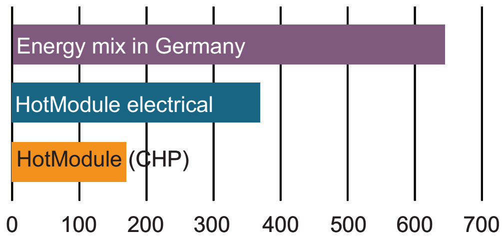

Figure 5: Comparison of CO_2 footprints (g CO_2/kWh).

Last, the nature of the exhaust is such that it is an “exhaust air” in the case of a HotModule fuel cell, to be compared with exhaust gases for all other production means. As a matter of fact, the German regulation on exhausts (TA Luft) is already fulfilled by fuel cells.

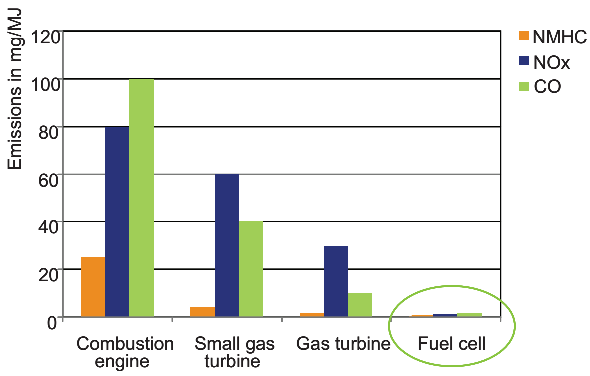

Figure 6: Comparisons of emissions for different technologies.

Table 1: MTU’s HotModule exhaust air characteristics compared with TA Luft requirements.

	HotModule*	TA Luft
SO_2	< 0,5 mg/m_n^3	350 mg/m^3
NOx	< 3 mg/m_n^3	500 mg/m_n^3
CO	< 9 ppm	150 ppm
Particulate	< 1mg/m_n^3	n/a

*HotModule CHP

4 Development Support in Germany

The industry has made significant investments in both the R&D around Fuel Cells and the facilities to grow production volumes. However, those investments need to be supported by governmental initiatives to compete with existing technologies. Those initiatives, whether through subsidies or regulations will be the stepping stones to start production in series, reduce fixed costs and accelerate the learning curve.

They a required in order to create a strong market in Germany; which the German players would leverage to export overseas.

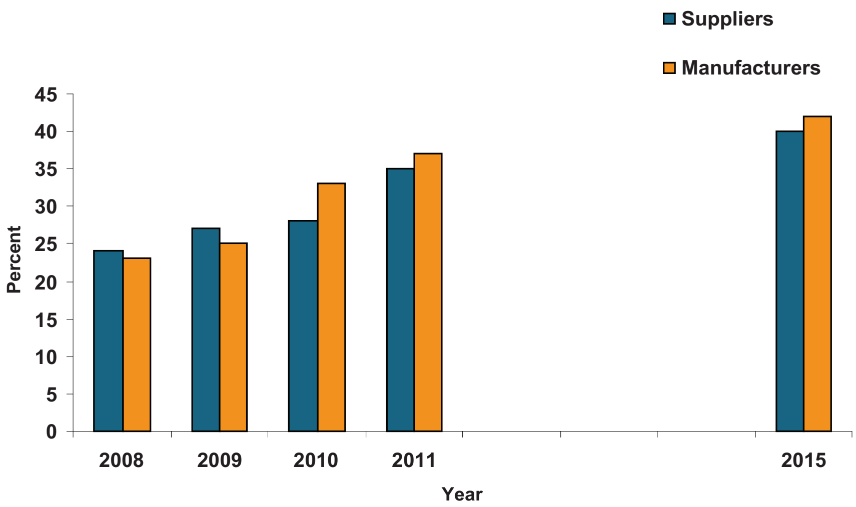

Figure 7: Percentage of sales through exports [4].

Germany has installed a fuel cell demonstration program called NIP (National Innovation Program for Hydrogen and Fuel Cell technology). However, it is a demonstration program only and does not support market deployment. Its end is scheduled for 2015; which creates substantial uncertainty. As a matter of fact, it is also clearly inferior to programs in the USA or in Japan as illustrated below:

Table 2: Comparisons of budgets for the development of fuel cells.

Jahr	DE	EU	USA	Japan
2001	19 Mio. €	36 Mio. €	126 Mio. €	157 Mio. €
2002	33 Mio. €	36 Mio. €	111 Mio. €	208 Mio. €
2003	33 Mio. €	69 Mio. €	186 Mio. €	306 Mio. €
2004	65 Mio. €	69 Mio. €	304 Mio. €	400 Mio. €
2005	65 Mio. €	69 Mio. €	402 Mio. €	430 Mio. €
2006	70 Mio. €	69 Mio. €	270 Mio. € (DoE)	260,3 Mio. € (METI)

Those programs are key as currently, the fuel cell cannot compete on a financial basis with substitutes, especially turbines or engines. The latter will generate a much higher rate of returns as they benefit from scale and 100 years of cost reductions and learning curve.

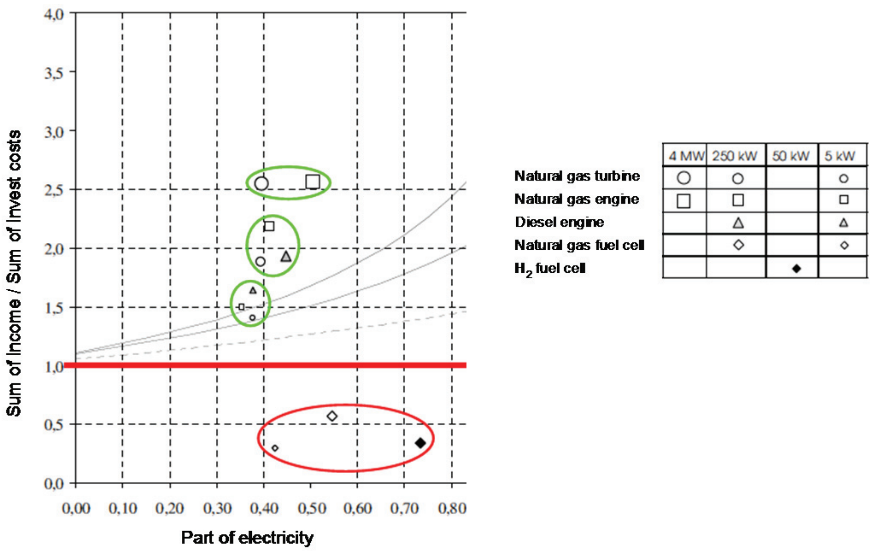

Figure 8: Compared economics of fuel cells, engines and turbines [5].

Figure 9: HotModule fuel cell HM300 at Germany's largest private brewery Erdinger Weißbräu.

Appendix

VDMA Fuel Cell Working Group Members
3M Deutschland GmbH
Baxi Innotech GmbH fuel cell heating
Bosch Rexroth AG
Bürkert GmbH & Co. KG
Buschjost Norgren GmbH + Co. KG
Das Institut für Industrielle Fertigung und Fabrikbetrieb, IFF
DEUTZ AG
DLR - Deutsches Zentrum für Luft- und Raumfahrt e.V.
Eisenhuth GmbH & Co.KG
EnyMotion GmbH
eZelleron GmbH
Fraunhofer IKTS
Fraunhofer Institut für Chemische Technologie (ICT)
Fraunhofer Institut für Solare Energiesysteme (ISE)
Freudenberg FCCT KG
FWB Kunststofftechnik GmbH
Gardner Denver Deutschland GmbH
Gebr. Becker GmbH
GHR Hochdruck-Reduziertechnik GmbH
Gräbener Maschinentechnik GmbH & Co. KG
Grundfos Management A/S
GSR Ventiltechnik GmbH & Co. KG
Heliocentris Energiesysteme GmbH
HNP Mikrosysteme GmbH
Hochschule für Angewandte Wissenschaften
h-tec Wasserstoff-Energie-Systeme GmbH
IRD A/S
IWAKI Europe GmbH
Karlsruher Institut für Technologie (KIT) Campus Süd Institut f. Werkstoffe der Elektrotechnik
Linde Material Handling GmbH
Magnum Fuel Cell AG
MTU Onsite Energy GmbH
Next Energy EWE-Forschungszentrum für Energietechnologie e.V.
Otto Egelhof GmbH & Co. KG Regelungstechnik
P21 GmbH
Plansee SE
PROTON MOTOR Fuel Cell GmbH
RBZ Riesaer Brennstoffzellentechnik GmbH
Rittal GmbH & Co. KG
Robert Bosch GmbH
ROFIN-SINAR Laser GmbH
Schunk Bahn- und Industrietechnik GmbH
Schwarzer Precision GmbH + Co. KG
SFC Energy AG
SGL TECHNOLOGIES GmbH
Siemens AG Energy Sector Fossil Power Generation
Siemens AG Industrie Sector Building Technologies Division GER I BT
SMA Solar Technology AG
Süd-Chemie AG
Truma Gerätetechnik GmbH & Co. KG
TRUMPF GmbH + Co. KG
TU Bergakademie Freiberg Inst. f. Wärmetechnik u. Thermodynamik Lehrst. f. Gas- und Wärmetechn. Anlagen

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UST Umweltsensortechnik GmbH
Viessmann Werke GmbH & Co.KG
WILO SE
WITTENSTEIN cyber motor GmbH
WS Reformer GmbH
ZBT gGmbHZentrum für BrennstoffzellenTechnik
ZSW Zentrum für Sonnenenergie- u. Wasserstoff-Forschung Baden-Württ. GB Elektrochemische Energietechnologien

References

[1] Source: liG Research, 2007

[2] This ranking shows great differences in the number of patents filed. However, while this difference cannot be understated, the numbers need to be interpreted as the Patent Office in Germany has a narrower approach than those of the US and Japan regarding what can be patented.

[3] Source: MTU, WIPO Statistics database

[4] Source: VDMA Fuel Cells Survey 2009

[5] Source: Institut für Zukunftenergiesysteme (IZES)