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B. Wang, U. Schüller, J. Garche

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German-Chinese H_2 & FC Activities in the Framework of the German-Chinese Sustainable Fuel Partnership (GCSFP)

Binggang Wang, **Ulrich Schüller**, Project Coordinator GCSFP
Jürgen Garche, FCBAT Ulm, Germany

1 Introduction

The sustained strong economic growth in the People's Republic of China is bringing about an increased demand for transport and mobility. The rapid increase in transport services is placing great demands on energy supply security, as well as on climate and environment protection.

In light of this situation, German and Chinese political and economic players have come together in the German Chinese Sustainable Fuel Partnership, based on intergovernmental agreement signed on December 1st 2003 by the German Federal Ministry of Transport, Building and Urban Development (BMVBS) and the Ministry for Science and Technology of the People's Republic of China (MOST).

The aim of this partnership is to develop alternative and sustainable concepts for energy supply and technology in the mobility sector, and to push ahead with their introduction.

By setting up pilot plants and constructing and operating fleets of vehicles, the project aims to demonstrate the utilisation of biofuels, synthetic fuels, hydrogen and electric mobility in the transport sector.

The activities of the GCSFP serve to exchange experiences and to economically develop new, sustainable technologies. The legal conditions (laws, regulations, guidelines) and the further development of standards and norms also have a role to play in this process, e.g.

- Strategic studies, e.g. "Strategy report on the development of fuels for road transport in the People's Republic of China" (see http://www.gcsfp.de/index.php?id=47).
- Workshops, e.g. the technical seminars "Hydrogen in mobile applications", "Biofuels and synthetic fuels" and "Electric mobility" in Germany and China, each with a comprehensive excursion programme.
- Conferences, e.g. "Clean Diesel Symposium" during the "Clean Vehicle Technology Exhibition and Conference" in Beijing
- Standardization projects, e.g. fuel standardization RIPP-Sinopec
- Demonstration projects, e.g. constructing and operating efficient taxi fleets, which are powered with synthetic fuel and fulfill particular requirements regarding emissions.

A very important role in the GCSFP program plays the mobility based on hydrogen and fuel cells. Deeper cooperation's in this field started with the Chinese-German H2&FC Workshop in Berlin (Germany), May 20th – 25th, 2007; (CD about this workshop is available at schuster@dena.de).

In the focus of that mutual H2&FC cooperation are the following projects:

1. Market introduction programs:

- Legal framework (regulations) for H2 vehicles
- Codes and Standards for H2 vehicles
- Test and measurement methods for H2&FCs (in preparation)

2. Basic research programs:

- Hydrogen storage materials
- Dynamic of PEFCs.

Besides these H2&FC projects there are also battery related projects in the framework of electro mobility:

- Study on Chinese and German Vehicle Battery Development
- Regulatory Frameworks for Electric Vehicles and Infrastructure in China and Europe/Germany
- Analysis and Comparison of Standards and Implementation Rules for the Application of Electric Vehicles and Vehicle Batteries
- Battery Safety Test Manual
- EV-Demonstration Project Rhein-Ruhr and Wuhan.

2 Analysis of the Legal Framework for a Hydrogen Infrastructure in China, as Prerequisite for a Harmonisation of the European/German and Chinese regulations

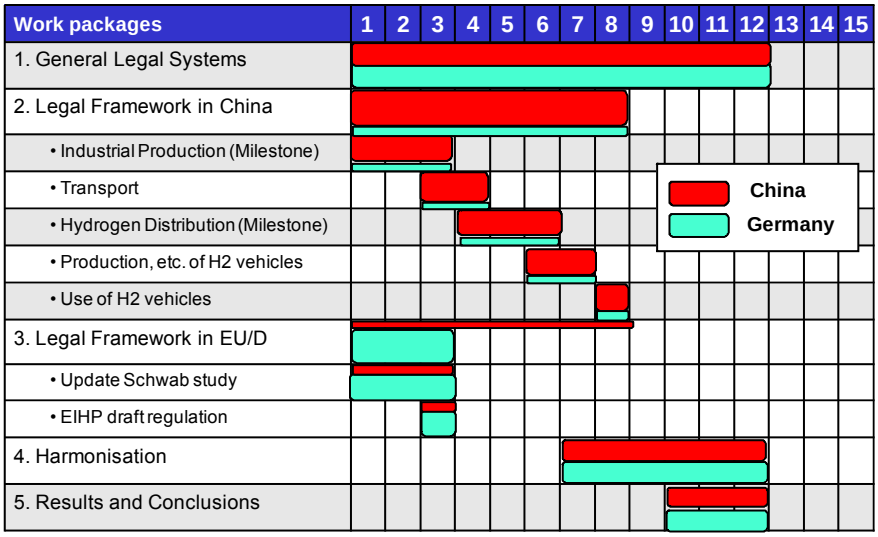
German partner: EnergieAgentur NRW, Düsseldorf
Chinese partner: Tsinghua University, Beijing
Project duration: Juli 2008 - Juni 2009.

2.1 Objectives:

The study is focused on the legal framework for a hydrogen infrastructure in China, Germany and Europe. Several laws, ordinances and standards were collected and scanned by lawyers in order to find out differences and similarities. The majority of the regulations come from the field of environmental, labour, health and safety law.

During the last time, China enacted several regulations concerning hydrogen and fuel cells, which shows the engagement in this field. Further standards focused on the technical details of hydrogen vehicles are in development and will be come into force soon.

2.2 Work programme:



2.3 Conclusion

Many regulations in China, Germany and Europe are similar, especially in the field of environmental and labour law. Chinese law is partly stricter in regard of safety distances to special physical structures. The classification of hydrogen as dangerous substance is similar in China and D/EU. Also the classification as dangerous good with the respective packaging groups is comparable.

China has a great interest in pushing forward international cooperation and ex-change of technologies and experiences, which is mentioned in the Renewable Energy Program, of China. Due to the fact that China emphasises hydrogen technology and the development of fuel cells, significant administrative barriers to introduce a hydrogen infrastructure are not expected.

At the current situation (mid of 2009) urgent needs for action is not necessary to harmonize regulation for a hydrogen infrastructure on road traffic between China and D/EU. Latest regulations are very similar in Europe and China. It is recommended to pursue the adoption of new laws and standards in China and Germany/EU. Each field of infrastructure should be monitored.

The project partners recommend signing a political Memorandum of Understanding (MoU) to inform the other side about the regulations in early draft versions.

Until now UN-classification and UN-labelling of dangerous goods are identically. The trend to use international regulations is effect of the globalization. Other international regulations which have to be implemented will follow. Also for that reason China and Germany should enforce their engagement in the working parties of the United Nations Committees. The project partners recommend presenting consolidated positions in UN Working Party 29 for Global Technical Regulations (GTR) for hydrogen vehicles. Except the GTR for hydrogen vehicles there are no other UN Working Parties working along the infrastructure at the moment. It is recommended to initiate new Working Parties in other fields of the hydrogen infrastructure for road traffic.

3 Analysis of the Situation of Standards and Codes for Hydrogen and Fuel Cell Vehicles and Related Supply Infrastructures

German partner: Ludwig-Bölkow-Systemtechnik GmbH (LBST)

Chinese partner: China Automotive Technology & Research Center (CATARC)

Project duration: November 2008 - April 2010.

3.1 Objectives:

Goals of the study were to analyse the present situation of Standards and Codes In Europe/ Germany and in China, to identify the differences and commonalities in Standards and Codes and to develop joint conclusions and suggestions towards international standardisation bodies.

3.2 Work programme:

The work program of the study was agreed as follows:

1. WP 1. General relevance of Standards and Codes for H2&FC vehicles in China and Germany/EU
2. WP 2. Analysis and exchange of Standards and Codes for H2&FC vehicles in China
   - 2.1. Transport of hydrogen on streets and rail;
   - 2.2. Hydrogen Refuelling Stations (as and example: Shell station in Anting, Shanghai);
   - 2.3. Approval and use of H2 vehicles
3. WP 3. Analysis and exchange of Standards and Codes for H2&FC vehicles in Germany/EU
   - 3.1. Transport of hydrogen on streets and rail;
   - 3.2. Hydrogen Refuelling Stations;
   - 3.3. Approval and use of H2 vehicles
4. WP 4. Results and conclusions
   - Differences Analysis {Gaps Analysis} (China/ D/ EU)
   - Suggestion of agreed approach towards international standardisation bodies

3.3 Important results:

The most essential difference between China and Europe with regard to the relevance of standards is that standards in Europe are voluntary agreements between private organisations like industrial companies for the harmonization of requirements for technical interfaces, whereas in China mandatory standards exist, which are attributed regulatory characteristics. These regulatory characteristics in Europe can only be derived from regulations or directives, i.e. legal requirements. China seems to lack a framework or outline directive similar to the one existing in Europe. On the other hand, Europe as well as China certify road vehicles via a whole vehicle type approval process (as also does Japan) and not through a self-certification process like applied in the USA.

As the Chinese partner CATARC did not provide inputs on infrastructure-relevant issues nor participated in the analysis of differences in C&S between China and EU/D any

recommendations provided could only be drafted by the German side without harmonizing them with the Chinese partner in time.

3.4 Conclusions and recommendations:

Under the WTO's TBT Agreement signed by both China and the EU, it is agreed upon to avoid the proliferation of national standards that differ from one country to the next, it is recommended that countries be encouraged to bring their work to ISO/IEC and to contribute to the development of ISO and IEC International Standards and to use or adopt them as required.

4 Hydrogen Storage Materials - Development, Upscaling and Testing of Nanocomposite Materials for Hydrogen Storage

German partners:

- Karlsruhe Institute of Technology, Karlsruhe (Project leader)
- Fraunhofer-Institut für Fertigungstechnik und Angewandte Materialforschung, Dresden
- GKSS Forschungszentrum Geesthacht GmbH, Geesthacht
- Max-Planck-Institut für Kohlenforschung, Mülheim/Ruhr

Chinese partners:

- General Research Institute for Nonferrous Metals (GRINM), Beijing
- Nankai University, Tianjin

Project duration: October 2009 – March 2012

4.1 Objectives:

The goal of this study is the development, optimization and realization of a hydrogen sorption tank system for combination with a high temperature PEM fuel cell (HT-PEM FC) aiming at automotive applications, primarily.

In close collaboration between German and Chinese partners, suitable nanocomposite solid storage materials shall be developed further and an upscaling of the fabrication will be performed. The synthesized material will be tested on the kilogram scale in a prototype-level sorption tank system under realistic operation conditions.

4.2 Work programme:

1. WP 1 - (MPI):
   - Laboratory studies on Li-boranate-based mixtures with MgH2.
   - Investigation of intermediates and search for catalysts.
2. WP 2 - (FZK):
   - Upscale studies of boranate based mixtures of MgH2. Optimization of parameters.
   - Production of material for WP 3.
3. WP 3 - (FhG IFAM):
   - Design and construction of hydride storage tanks
   - Implementation in realistic tank test

- Environment and system integration with HT-PEM

4. WP 4 - (GKSS):

- Laboratory studies on Li-Ca-B-H and comparative screening of current H storage materials.

4.3 First results:

The work has started in the different WPs and first results have been achieved related to improved properties of nanocomposites made from borohydrides and Mg hydride and from amide based materials. Further investigations are under way. Moreover, experimental work focused on investigation of thermal properties of hydrides which were mixed with expanded natural graphite in order to improve the heat conduction properties. Therefore, cylindrical compacts were produced which show superior safety and heat conduction properties.

5 Experimental Study to the Dynamic Operation of PEMFC-Stacks

German partner: Zentrum für Sonnenenergie- und Wasserstoff- Forschung (ZSW), Ulm,
Chinese Partner: Dalian Institute of Chemical Physics (DICP), Dalian,
Project duration: October 2009 - September 2011

5.1 Objectives:

Lifetime of PEFC - Stacks with highly dynamic operation like in automotive applications is significantly shorter than the lifetime of comparable stationary Stacks caused by their high dynamic operation conditions.Therefore the project focus is to improve the lifetime of automotive PEMFC.

5.2 Work Programme:

ZSW

1. WP1 - Parameter definition and evaluation

- Definition of operation & measurement parameters; Evaluation/development of appropriate
- measurement methods & test benches and hardware for data logging

2. WP2 - Experiments

- Acquisition / development / construction and test of measurement methods and test benches;
- Manufacturing of short stacks with different GDL & flow field designs; Stack measurements with
- high dynamic operation including Start / Stop – procedures; Examination of selected operation
- states with neutron radiography

3. WP3 - Modeling

- Fluent Modelling of different flow field geometries

- Step 1: stationary 1-dimensional calculation, identification of critical areas; Step 2: dynamic
- calculation, identification of critical states; Step 3: implementation of Fluent PEM - Modul

4. WP4 - Validation

- Results of AP2 & AP3 → optimized flow field and GDL for dynamic operation will be constructed /
- elected and tested; Development of suitable operation strategies for dynamic operation; Construction and testing of a full sized Stack (≥ 20 cells) with optimized flow fields and GDLs.

DICP

1. WP1 - Measure the distributions of local current, temperature and voltage in a 300cm^2 cell in DICP; Compare the measurement results with those of 100 cm^2 cell from ZSW; Study the start/stop process.
2. WP2 - Investigate the fuel starvation behavior of a separated cell in a short stack in DICP; Change the cell parameters; Compare the test results with those of ZSW.
3. WP3 - Test the influence of different MEA structures (different catalyst, GDL and membranes) on the dynamic behaviour.
4. WP4 - Test the water distributions in different dynamic processes with a small DICP stack in Germany.

5.3 First results:

A test bench for high dynamic operation of PEFC Stacks is developed and currently under construction. A circuit board for locally resolved current density measurements under high dynamic operation is developed and currently under construction.

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- Zongqiang MAO, Tsinghua University Beijing, maozq@tsinghua.edu.cn

2. Codes and Standards Project:
- Reinhold WURSTER, LBST Ottobrunn, wurster@lbst.de
- Yuntang HE, CATARC, heyuntang@catarc.ac.cn

3. Hydrogen Storage Material Project:
- Maximilian FICHTNER, KIT Karlsruhe, fichtner@kit.edu
- Shumao WANG; GRINM Beijing, wsm1963@sohu.com

4. Dynamic of PEMFCs Project:
- Günther SCHLUMBERGER, ZSW Ulm, guenther.schlumberger@zsw-bw.de
- Ming HOU, DICP Dalian, houming@dicp.ac.cn