FCCF-APU

Fuel **C**ells operating on **C**onventional **F**uels as **A**uxiliary **P**ower **U**nit for battery electric vehicles

ERA-NET Transport Electromobility+ Midterm Review Meeting,
6th – 7th February 2014, Copenhagen, Denmark

SEVENTH FRAMEWORK PROGRAMME

WS Reformer GmbH

CHALMERS

Sertenergy® The Power of Simplicity

Fraunhofer ISE

IMPACT COATINGS

borit®

Fraunhofer ICT

Danish Power Systems®

Federal Ministry of Economics and Energy

Electromobility+

FCCFAPU FUEL CELL OPERATING ON CONVENTIONAL FUELS AS AUXILIARY POWER UNIT

Fraunhofer ICT

Outline

- Motivation and goal of the project
- Contribution to the kex dimensions
- Challenges and project structure
- Progress at midterm
  - WP 1: System design
    (WS Reformer, Serenergy and Fraunhofer ISE)
  - WP 2: Membrane electrode assemblies and anode catalyst
    (Danish Power Systems and Fraunhofer ICT)
  - WP 3: Metallic bipolar plates
    (Borit, Impact Coatings, Serenergy and Chalmers)
  - WP 5: Conventional Fuel Reformers
    (WS Reformer and Fraunhofer ISE)
- Dissemination actions
- Conclusions
- Acknowledgements

Motivation and goals

- Battery electric vehicles (BEV) allow for (local) emission free driving and the use of renewable electricity for transportation.
- However, their operating range is limited and depending on e.g. weather conditions
- To increase the operational reliability of BEV is an important goal in particular for commercial applications.
- This requires that parasitic energy consumption, e.g. for lightning, heating or air conditioning is covered from an additional power source (APU).
- Using a fuel cell as power supply helps to maintain the desired low emissions and low noise level.
- An APU combining a HT-PEMFC with a steam reformer for diesel or petrol was found most suitable for this application
  - It avoids infrastructure burdens by using conventional fuels.
  - It offers a good efficiency to keep CO_2 emissions and an acceptable level.
  - It is less sensitive towards start-stop cycling and uses less energy herein than SOFC based solutions.

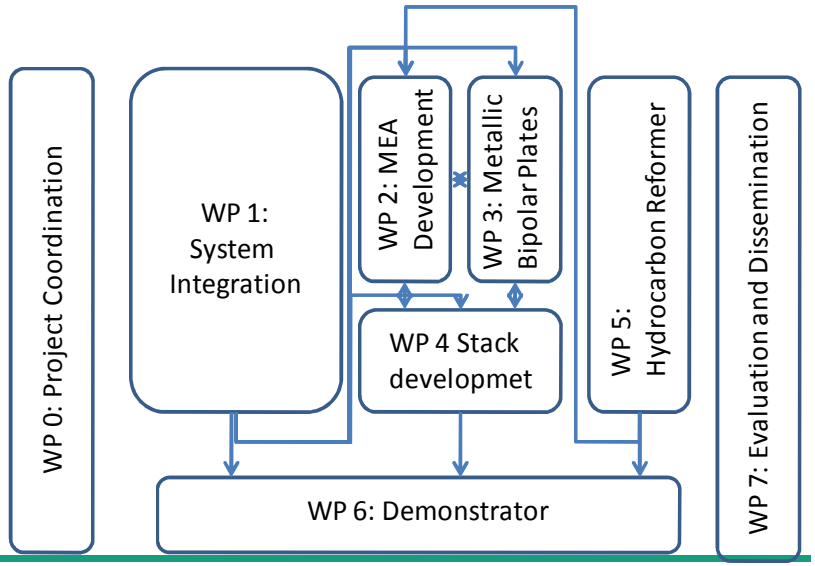
Contribution to the key dimension

- With its goal the project direct contributes to the key dimension 5 “Technology based innovation” (conf. Guide for Applicants)
- In this key dimension specifically the issue 5.e “Auxilliary Power Units” is addressed.
- The focus of this project therein is on APU for battery electrical road vehicles in particular light duty vans
- However, a future scale up to other significant applications mentioned in the guide for application is not excluded.

Strategy and Goals

- In order to achieve the set goals some challenges need to be met.
- The systems needs to operate water autonomous requiring an adequate system design.
- The MEAs need to become more resilient against high humidity levels and impurities such as sulphur.
- The stack needs to be reduced in size and weight.
- The reformer needs to be adapted for liquid fuels and catalyst found for diesel and/or petrol
- The system needs to be integrated.

Property		Target Value
Net power output		3 kW_{el}
Weight		< 150 kg
Volume		< 225 l
Efficiency	during operation	≥ 28% electrical energy to fuel (LHV)
	eff. incl. start-stop	≥ 25% electrical energy to fuel (LHV)
Target price		12,000 €/pc mass production



Progress ad midterm: WP 1 system integration

Fraunhofer ISE WS Reformer GmbH Serenergy The Power of Simplicity

- Currently the following has been accomplished
  - A commercial natural gas reformer of WS Reformer was successfully modified by WS Reformer to accommodate liquid fuels.
  - A prototype was delivered to Fraunhofer ISE and tested with methanol.
  - A commercial 1 kW HT-PEMFC stack was delivered by Serenergy to Fraunhofer ISE
  - This stack has been fully characterised by Fraunhofer ISE
  - A simulation model for the entire system was created.
  - A concept for water autonomous operation till 40 °C was developed and validated by simulation.
- Next steps
  - Hardware set-up of the entire system as functional module
  - Verification of the simulation by experiments

Progress ad midterm: WP 1 system integration

Fraunhofer ISE

WS

Serenergy
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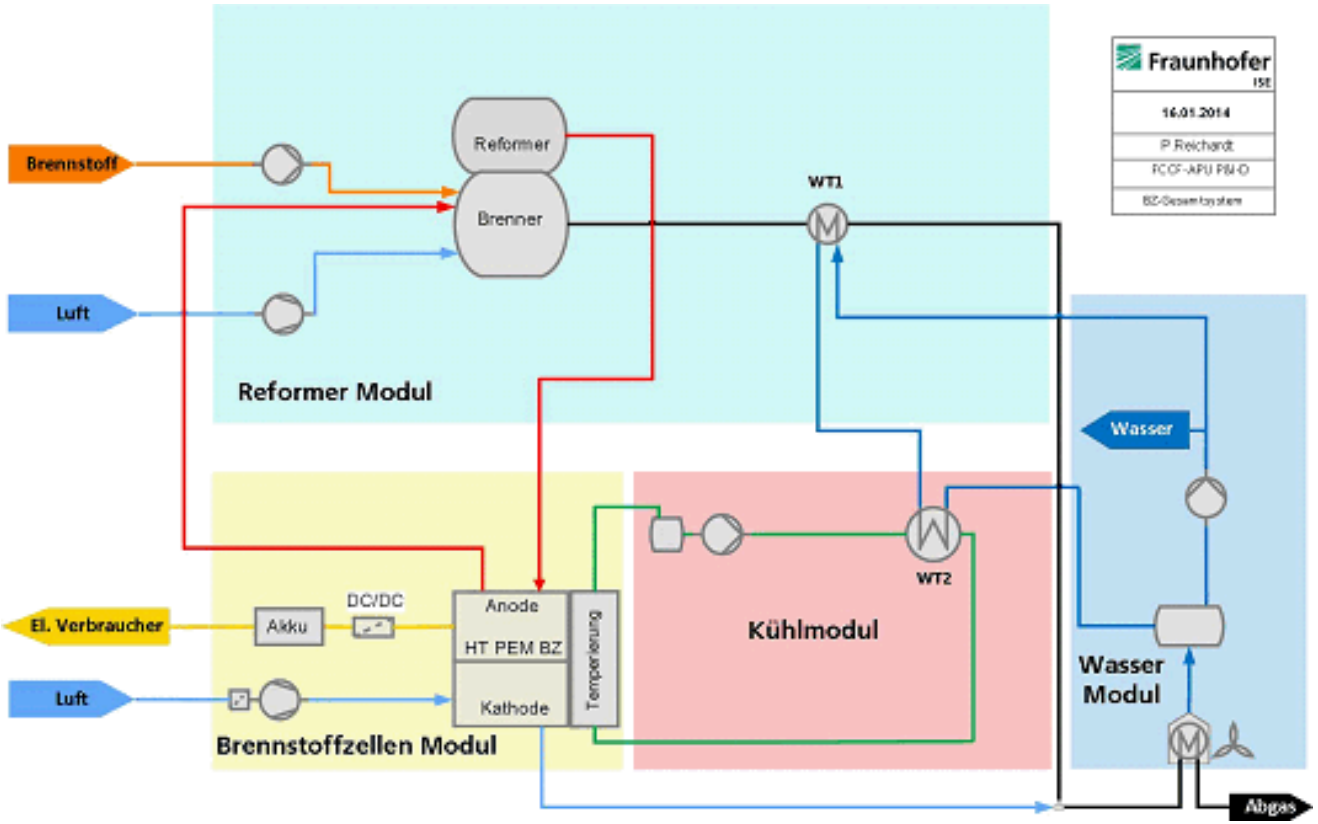


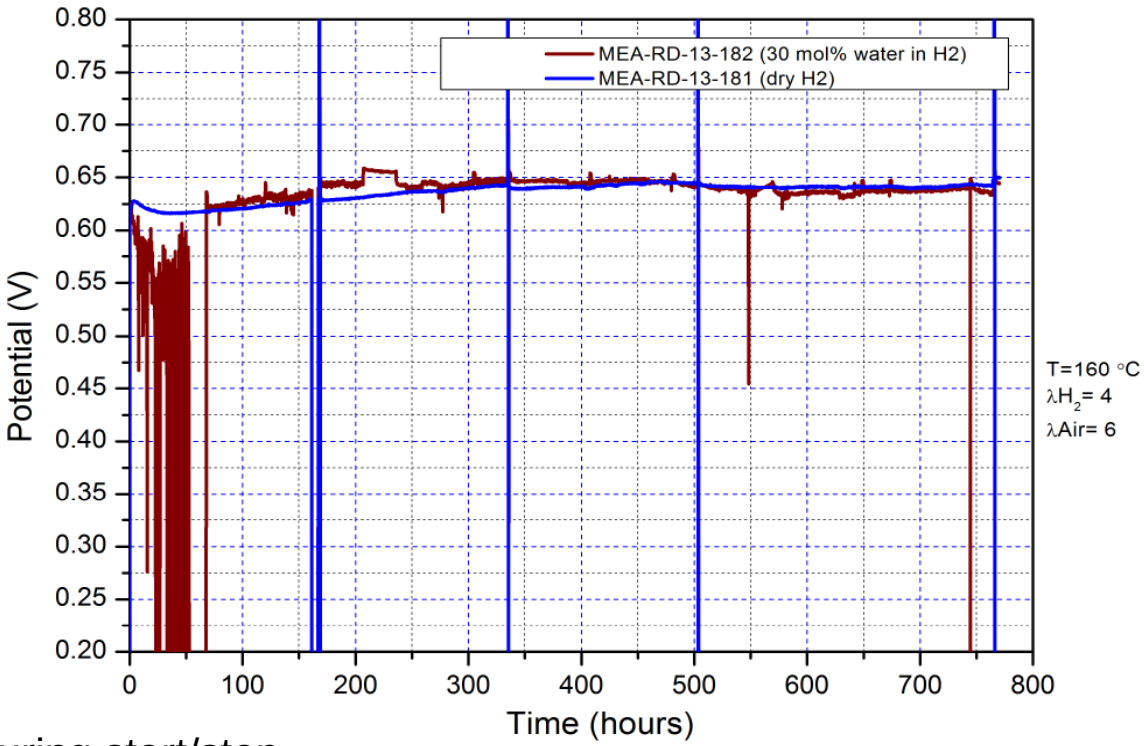
Progress at midterm: WP 2 MEA

Danish Power Systems®

Fraunhofer ICT

Danish Power Systems:
The main objective is to develop and manufacture MEA's for the APU unit.

Preliminary results:
Improving the hydrophobicity of the MEA's has resulted in a significant improvement in the durability when using wet fuels
(30% water):



Next step:
Improved durability of the MEA during start/stop.

Progress at midterm: WP 2 MEA

Danish Power Systems®

Fraunhofer ICT

Fraunhofer ICT

An important objective is to find anode catalysts with higher tolerance for fuel impurities in particular sulphur.

Preliminary results

Different PtM/C catalyst were tested for their hydrogen oxidation activity after H_2S exposure.

Two candidates A and B were identified which show promising properties, with B being a non-PGM

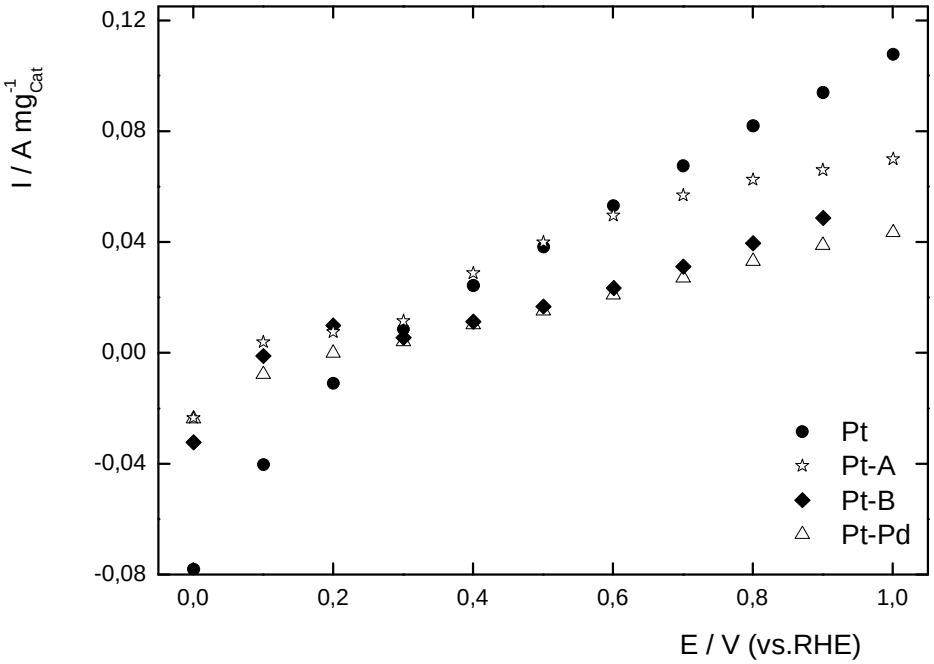


Figure 2: Dependence of the current with the overpotential for the hydrogen oxidation reaction in presence of H_2S for different materials.

Next steps

Tests in actual MEAs and transfer into Danish Power Systems MEAs

Progress at midterm: WP 3 Metallic bipolar plates

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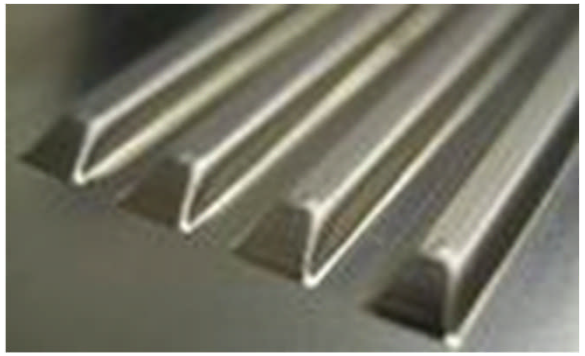
Accomplishments

- BPP design: Completely new design for metallic plates developed in several iterations based on existing design for carbon plates
- Elaboration of test matrix for combinations substrates / coatings and prioritization
- Production of test samples according to test matrix
- Electrochemical testing and first evaluation
- Selection of substrate/coating for demonstrator: SS316L/Ceramic Max Phase
- Production of bipolar plates for short stack testing



Progress at midterm: WP 3 Metallic bipolar plates

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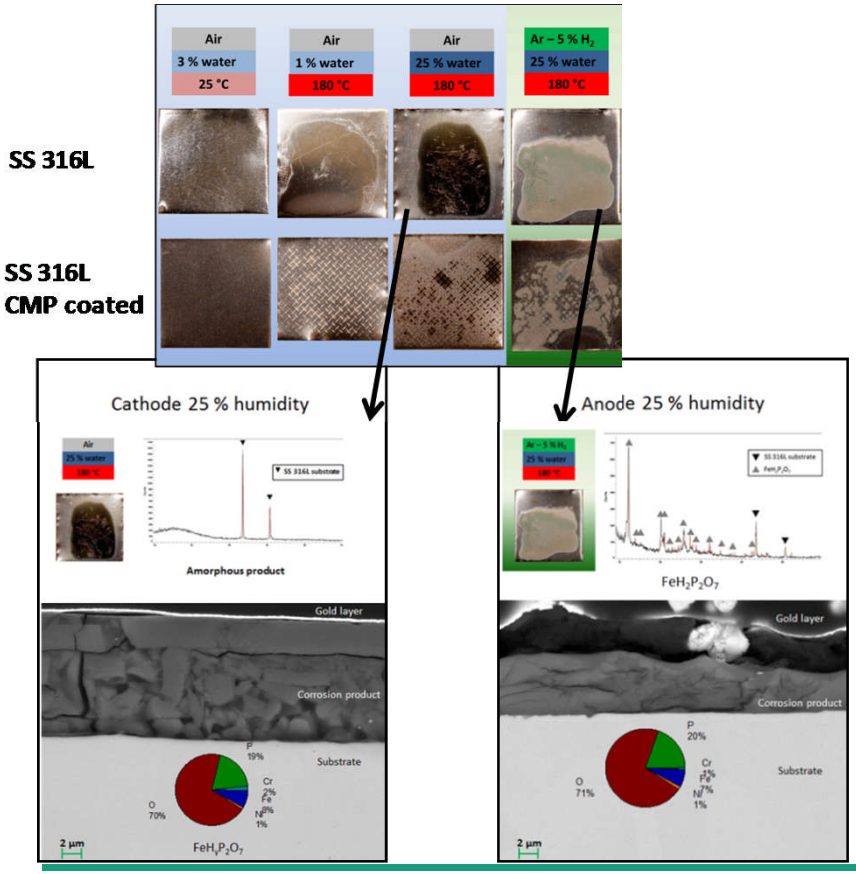
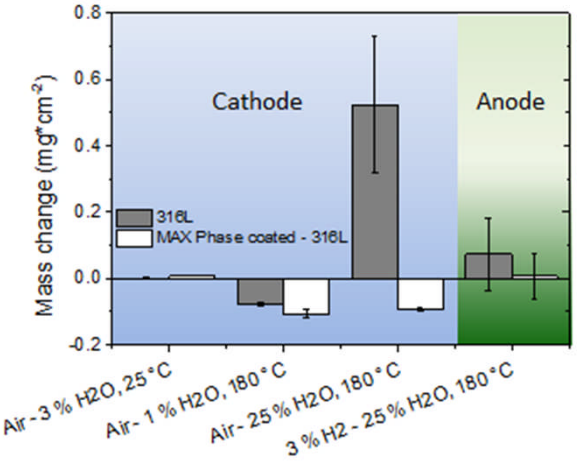
Exposures in controlled environments for 168 h



Mass change



Severity of corrosion increases:

- Humidity
- Temperature
- Oxygen content (cathode)

<u>Performance can be increased by Ceramic Max Phase coatings</u>

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Progress at midterm: WP 3 Metallic bipolar plates

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Next steps

- Optimisation of joining technology (laser welding)
- Production of bipolar plates for demonstration stack
- In situ testing
- Evaluation

Progress at midterm: WP 5 Reformer

Fraunhofer ISE

WS Reformer GmbH

- Currently the following has been accomplished
  - Selection of four commercial candidate catalyst from two different suppliers
  - Tests of the catalysts in test rig with actual diesel
  - Selection of the most suitable catalysts
  - Calculation of the catalyst requirements for the full scale reactor
- Next steps
  - Set-up of a full scale diesel reformer

Dissemination actions

- A web presence for the project has been created under the URL www.fccf-apu.eu
- A flyer of the project was created in February 2013 and distributed by partners at the following trade fairs
  - FC-EXPO 2013, Tokyo (Japan)
  - Hannover Messe Industrie 2013, Hannover (Germany)
  - f-cell 2013, Stuttgart (Germany)
  - Fuel Cell Seminar and Exhibition 2013 Columbus, OH (USA)
- Presentations on project results by Chalmers (oral) and the Fraunhofer ICT (Poster) were given at the European Fuel Cell Forum, Lucerne (Switzerland)
- An further oral presentation at the European Hydrogen Energy Conference in Sevilla, Spain has been accepted.

Conclusions

- In spite of some delay which was encountered by the withdrawal and replacement of an important partner in June 2012 good progress in all work packages has been made.
  - A system concept based on the current commercial version of stack and reformer has been developed
  - Improvements in MEA technology have been demonstrated
  - Metallic bipolar plates will be manufactured and tested soon in actual stacks
  - A suitable catalyst for diesel reforming has been found.
- The next steps towards the realisation of the demonstrator have begun.

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