

Fuel cells and hydrogen

Joint undertaking

MCFC-CONTEX

MCFC catalyst and stack component degradation and lifetime:
Fuel Gas CONTaminant effects and EXtraction strategies

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Topic: SP1-JTI-FCH.3.3 Degradation and lifetime fundamentals.

- **Publication of call:** 8th October 2008
- **Proposal submitted:** 15th January 2009
- **Proposal accepted:** 5th June 2009

- **Project number:** 245171
- **Start of Project:** 1st January 2010
- **End of Project:** 31st December 2012
- **Budget:** EUR 4,429,336 eligible costs
- **Funding:** EUR 1,841,929 (41.5%)

MCFC-CONTEX, for society:

- **Reduction of dependence on fossil fuels**
 - *Focus on biogas from anaerobic digestion*
 - *Investigation of properties, contents, contaminants*
 - *Clean-up of critical contaminants for conversion*
- **Reduction of waste and wastefulness**
 - *Use of >100 kW-scale Molten Carbonate fuel cells*
 - *Maximize robust conditions in terms of poisoning*
 - *Define and predict contaminant tolerance*
- **Reduction of harmful CO₂ emissions**
 - *Investigate MCFC capacity to separate CO₂ from flue gas*
 - *Establish tolerance to cathode-side contaminants*

Project achievements

Industrial drivers and project targets

MCFC-CONTEX, for industry:

- Cost-effective biogas clean-up system for HTFC
- Definition and prediction of safe operating frame for MCFC
- In-depth, real-time analysis of biogas quality

WP3

- Development of combined Laser-induced plasma & Raman spectroscopy
- Calibration and qualification with real biogas

WP2

- Definition of limit operating conditions
- Numerical model predicting poisoning effects & lifetime
- Accelerated testing protocols

WP4

- Screening of commercial clean-up materials
- Development of clean-up system tailored for HTFC
- Prototype validation

MCFC-CONTEX, milestones:

WP2

MS 2.1	Basic model on standard cell operation
MS 2.2	Preliminary definition of Accelerated Testing procedures
MS 2.3	Report on poisoning mechanisms and effective tolerance limits for MCFCs in different operating conditions
MS 2.4	Model on the effects of residual impurities and CH ₄ content in reformat
MS 2.5	Accelerated Testing protocols

WP3

MS 3.1	Laboratory scale sampling and real-time gas analysis and contaminant detection system
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WP4

MS 4.1	Comparison of gas cleaning performance of selected cleaning technologies
MS 4.2	Operating lab-scale gas cleaning unit fulfilling the MCFC requirements.

MCFC-CONTEX, approach:

- Define list of contaminants and gas compositions
- Define system boundary and operating conditions

Then:

WP2

- Button cell prelim. tests
- Harmonization of test conditions
- Cell tests in real conditions
- Numerical model set-up
- Model validation
- Accelerated testing protocols

WP3

- Evaluation of sampling methods
- Development & calibration of LIBS system
- Development & calibration of Raman system
- Integration in 19" rack

WP4

- Characterization of adsorptive materials
- Characterization of reactive materials
- Design & dimensioning of clean-up system
- Prototype realization and validation
- Design scale-up

MCFC-CONTEX, results at M18:

WP2

- Button cell tests carried out on S-compound poisoning (an. & cat.)
- Screening test conditions harmonized and validated
- Measurement conditions and results shared
- Basic numerical model set up and under validation

WP3

- Sampling method selected
- Development of LIBS system completed: under calibration
- Design of industrial-scale 19" rack done, integration in progress

WP4

- Characterization of adsorptive and reactive materials ongoing, at different stages of clean-up system
- Preliminary design & dimensioning of clean-up system underway

MCFC-CONTEX, addressing MAIP:

- **“To improve the technology for fuel cell stack and balance of plant components to the level required by the stationary power generation and CHP markets”**
 - By verifying the limiting operating conditions for durable operation of the MCFC, the control system can be optimized, reducing cost and increasing lifetime of the MCFC system
 - Accurate monitoring of gas quality will allow for effective system control
 - The clean-up system is a crucial item of the BOP, needs to be as cost-effective as possible, robust, reliable, longer life time

MCFC-CONTEX, addressing MAIP:

- **“Long-term and breakthrough orientated research will concentrate on degradation and lifetime fundamentals related to materials and typical operation environments for all power ranges”**
 - In-depth research into the poisoning mechanisms (experimental & numerical) will allow for effective prediction of critical conditions and help to develop improved components with higher tolerance
- **“to deliver [...] reliable control and diagnostics tools both at a component and at system level. ”**
 - Real-time, on-line, in-depth gas quality monitoring is a key tool to a competitive MCFC system

MCFC-CONTEX, addressing AIP:

- **Novel designs solutions, and optimisation of components to be integrated with industrially relevant stacks**
 - A tailored fuel gas clean-up system has been designed and focused experiments are ongoing to quantify the material and dimensions of the industrially-ready system
 - Elemental gas quality monitoring of all process flows achieved with LIBS: calibration is ongoing
- **Validation and testing of components lifetime, durability/robustness in 'application' environment - life testing, failure mode analysis**
 - Systematic testing is underway from button cell to short stack to identify poisoning mechanisms and evaluate their effects
 - Numerical modelling and accelerated testing are called for: the basic model is ready

MCFC-CONTEX, addressing AIP:

- **Manufacturing process/technologies and manufacturing control techniques**
 - Fuel gas conditioning is a key process: preliminary results are available on the clean-up of sulphur compounds and siloxanes
 - The control of the system is heavily dependant on the assessment of gas quality: fluctuating compositions need to be identified in real-time. After proof of concept, now calibration of the analytical system within the expected operating range is underway

- **Safety, Regulations, Codes and Standards**

- Testing procedures are shared and applied in the experimental characterization campaigns

- **Dissemination & public awareness**

- Project website and intranet set up, first articles published. As project obtains success, increased promotion can take place

<http://mcfc-contex.enea.it/>

- **Technology Transfer / Collaborations**

- Thanks to international collaborations with S-Korea and USA, MCFC-CONTEX enjoys world-wide interest, leading to global validation of the results obtained
- Negotiations for further collaboration are underway with a similar project in France

- **Project Future Perspectives**

- Major disruption in Consortium due to closing of Ansaldo FC and MTU at month 18
- MTU will continue in joint venture with Fuel Cell Energy (USA) and Fraunhofer IKTS (D) to maintain a European MCFC base
- Survival of MCFC-CONTEX project guaranteed by the interest of FCE (External industrial advisor) and Fraunhofer (in charge of MTU Intellectual Property)
- Wide applicability of the project deliverables (clean-up system, gas quality monitoring, poisoning mechanisms understood and modelled) calls for project completion
- Possible follow up: the use of MCFC as retrofitting of conventional existing power plant as CO₂ concentrator/separator

Useful References

- **Fuel Cells and Hydrogen Joint Undertaking (FCH JU)** – Programme Office

<http://www.fch-ju.eu/>

- **FCH JU reference documents** (incl MAIP/AIPs)

<http://www.fch-ju.eu/page/documents>

- **European Industry Grouping** for Fuel Cells and Hydrogen, **NEW-IG**

<http://www.fchindustry-jti.eu>

- **European Research Grouping** for Fuel Cells and Hydrogen, **N-ERGHY**

<http://www.nerghy.eu>

- **European Commission** non-nuclear Energy Research (incl FCH)

http://ec.europa.eu/research/energy/eu/research/index_en.htm