Final report

1.1 Project details

Project title	DC/DC Converter-based Diagnostics for PEM systems (D-Code)
Project identification (program abbrev. and file)	64010-0113
Name of the programme which has funded the project	EUDP
Project managing company/institution (name and address)	Dantherm Power A/S
Project partners	Only Dantherm Power A/S has received EUDP topping up in this project. The partners in the FCH—JU funded project are: • Università degli Studi di Salerno • European Institute For Energy Research • Université de Franche-Comté • Dantherm Power A/S • CIRTEM • Bitron S.p.A • Inno TSD SA
CVR (central business register)	30804996
Date for submission	25/8/2014

1.2 Short description of project objective and results

Please see Annex 1 - Final Report D-Code

1.3 Executive summary

Among the main technological challenges of PEMFC System (PEMFCS), long duration, reliability and optimal working operations of both stack and auxiliaries are issues of primary importance. Solving these problems will give a great opportunity for a decisive breakthrough towards mass diffusion of the current PEM technology. The need for advanced diagnostic tools is of prominent significance to improve the lifetime of PEMFCS. Diagnostic algorithms can detect malfunctioning of components and give alarms for faults that may hinder correct operations or induce system's failures. The D-CODE project has developed an innovative monitoring procedure to support the diagnosis of PEM fuel cell stack for fault identification. The stack electrochemical impedance spectrum (EIS) is proposed for on-line diagnosis during on-field operations. To synthesize in a statement: the project implements the idea that a single measure (i.e. EIS) provides holistic information on the stack. Indeed, EIS is the most reliable diagnostic tool for FC and the project D-CODE moves the EIS-based diagnostic from laboratory to on-field. Therefore, the main issue was to transpose the EIS from lab-scale to on-board as well as to develop innovative FC stack monitoring to change radically the concept of on-line diagnosis. In perspective, on-board EIS may support stack degradation level analysis as well as lifetime prediction and effective control to mitigate the consequences of degradation due to chemical, thermal and humidity effects as well as load cycles or faults.

To cover most of the prospective stationary use of PEMFCSs (µCHP, backup and APU), two PEM technologies were considered, namely low temperature (LT) and high temperature (HT) for both high voltage (HV) and low voltage (LV) applications. Moreover, an additional device with a dedicated diagnostic function was developed to monitor the status of the stack when the FCS is switched-off. Towards the objective of implementing the EIS-based diagnostic functions on board of a FCS, the project addressed the development of new hardware and diagnosis algorithms that were embedded into the FCS. Moreover, a comprehensive experimental campaign was performed to identify the behaviour of the FC stacks under abnormal operating conditions to look into the influence of auxiliary devices (BoP) on stack impedance, as well as to validate the developed diagnostic algorithms. Another objective was building a diagnostic tool which may be implemented into any FCS with the minimum change of both hardware and software. Therefore, flexibility and modularity were also addressed during hardware and diagnosis algorithms design.

Two DC/DC converters for LV and HV uses were built and connected to an EIS-oriented controller board, which may be either implemented in any converter or connected via communication interface. The main feature of such a board is the control of voltage and current converter loops to inject the current stimuli to perform the EIS. This configuration guarantees the maximum flexibility to make the EIS-based diagnosis easy to install on any PEMFCS by substituting the conventional DC/DC converter or by adding the EIS control board. Three diagnostic algorithms were implemented making use of two approaches, namely model- and knowledge-based. The validation of these algorithms was successfully performed achieving the isolation of the following abnormal operations: air and fuel starvation, flooding, drying. A diagnostic tool was built and embedded into the controller of the FCS tested during the project. It was easily interfaced thanks to the use of conventional software functions and standard communication protocols. This guaranteed the development of a diagnostic tool that has industrial standards and marketable potentialities and is potentially implementable in any FCS.

Thanks to both the new DC/DC converter hardware and diagnostic algorithms, faults and potential failures associated to electrochemical processes, components faults (e.g. blower, power electronics, actuators) or having external origin (erroneous control, critical load) can be detected on-line while the system runs. Moreover, the main D-CODE project concept can be easily applied to other FC technologies (e.g. SOFC) thanks to the "universal" hardware and generic theoretical and experimental methodologies implemented.

1.4 Project objectives

Please see Annex 1 - Final Report D-Code

1.5 Project results and dissemination of results

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1.6 Utilization of project results

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1.7 Project conclusion and perspective

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Annex

Annex 1: Final Report D-Code (FCH-JU)

Project home page: https://dcode.eifer.uni-karlsruhe.de/