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AUTORE (AUTOMOTIVE DERIVATIVE ENERGY SYSTEM): 2 YEARS IN

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***Abstract* – AutoRE is a multi- partner project funded under the FCH-JU FCH-02.5-2014 call, aimed at demonstrating an automotive derivative fuel cell integrated with a natural gas reformer to make the required high purity hydrogen. The system prototype, to be demonstrated at GE's Rugby site in the UK, has a targeted electrical efficiency of 38-40%, with parallel component developments, such as hydrogen separation membranes, undertaken to increase the efficiency of a subsequent commercial system to >45%. The market for the product will be 50-100kWe applications in industrial and commercial buildings in combined heat and power (CHP) mode. At this scale, the fuel cell based CHP system has potential cost of electricity and emissions advantage over competing technologies. The project is now in its third year, with the build of the prototype system significantly underway. This paper gives the status of the project as reported at the mid-term meeting.**

***Index Terms* – PEM fuel cell, natural gas reformer, CHP, 50kWe demonstration**

I. INTRODUCTION

A. *Project Objective*

The aim of the AutoRE project is to create the foundations to commercialise an automotive derivative fuel cell system in the 50-100 kWe range, for combined heat and power (CHP) in commercial and industrial buildings. More specifically the objectives are to:

- develop system components allowing reduced costs, increased durability and efficiency
- build/validate a 50 kWe PEM prototype CHP system

The respective roles of the project partners to achieve these objectives are shown in Table I.

Table I. Role of AutoRE partners

Partner name	Role
Alstom UK	• Project Management • 50 kW system set-up, testing and validation • Performance modelling
GE Switzerland	• Dissemination • RAMS modelling • 3D printing HEX/reformer prototype manufacturing
Helbio	• Reformer manufacturing and commissioning • Control system • System integration support • Testing of PEM short stacks on reformate
Daimler /NuCellSys	• Manufacturing and commissioning of fuel cell automotive system and two short stacks. • Support in control system integration, diagnostic on FC system support.
Uni Split	• Diagnostic • New concepts for cogeneration
Unitus	• Performance modelling of test rig, final system • Modelling of integration of fuel cell system in a building environment
SINTEF	• Membrane development and testing, diagnostic modelling

II. RESULTS ACHIEVED TO DATE

A. *50 kWe Prototype System*

The fuel cell CHP prototype facility is shown schematically in Figure 2.

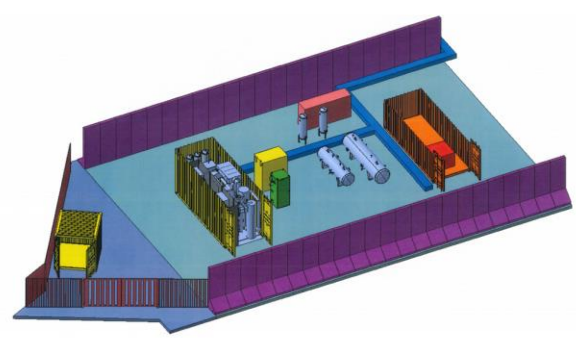

Fig 2: 3D Model of Prototype Test Facility Layout

The Fuel Cell Container including the automotive derivative PEM fuel cell supplied by NuCellSys has been installed. The

H2 production unit is in the final stages of commissioning with delivery to the prototype test site in Rugby UK scheduled for Jan 2018. This latter item has been held up significantly, most recently due to a corrosion issue within the reformer causing unacceptably high pressure drop, but this has now been rectified by using corrosion resistant FeCrAlloy material.

B. Component Development and Testing

Lab-scale testing of enhancements to the prototype system, to reduce its cost of electricity/foot-print and increase its performance are underway. Testing of selective membranes (to replace the Pressure Swing Absorber (PSA) unit to produce high purity H2) with increased system efficiency has been carried out (Figure 3). Compared to the baseline configuration, cooling and dehydration of the reformed natural gas feed before the H2 purification step are not required. Innovative heat exchanger design concepts using selective laser melting have been prepared to reduce the size of heat exchangers within the H2 production unit and improve their efficiencies. The final lab-scale testing carried out is that of short stack PEM fuel cell units at different operating conditions. Increasing the proportion of CO2 reduced the performance of the fuel cell, although this performance was fully recovered when pure hydrogen fuel was re-introduced. The decline in performance was attributed to CO poising, where CO is formed following the reverse water gas shift reaction.

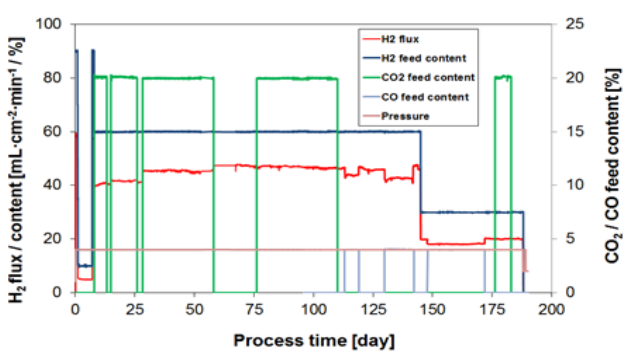

Fig 3: Hydrogen Membrane Testing Results

C. System Modelling

Extensive modelling of the fuel cell based CHP system has been carried out, both for the baseline configuration (Figure 4) and including future design improvements such as replacement of the PSA with a selective membrane based system. The outcome of the modelling at this stage is that whilst increasing the nominal power of the fuel cell section of the CHP plant has a certain positive impact on plant performance, its adoption should be subject to careful economic evaluation. On the other hand, thermal integration of the reformer improves the plant performance without drawbacks and should be adopted. Selective membranes should be integrated in the water gas shift reactor of the H2 production unit (and not used as a standalone component) and allows significant efficiency improvements if the H2 pressure can be reduced.

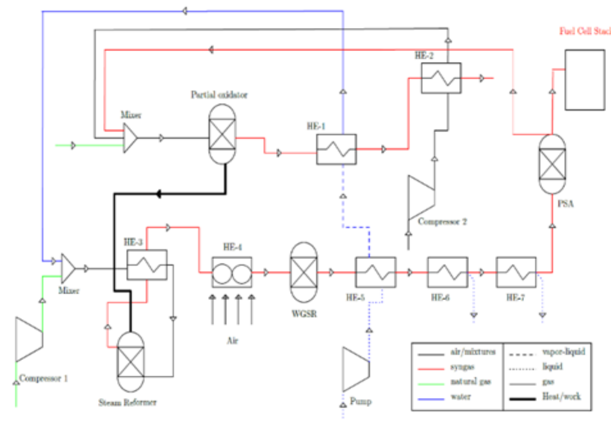

Fig 4: Schematic of the CHP plan concept: energy system

Additional modelling is underway to look at aspects of the plants reliability, availability and maintainability, and to look at fuel cell degradation. This latter modelling activity has leveraged on the results of a previous project (SAPPHIRE) which also targeted a CHP fuel cell system.

III. CONCLUSION

The AutoRE project remains on track to deliver the project objectives. Key results from the project are due in the final year, particularly the 3000h prototype tests.

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