Project no. **031414**

Project acronym: **METHAPU**

Project title: **Validation of Renewable Methanol Based Auxiliary Power System for Commercial Vessels**

Instrument: Specific Targeted Research Project

Thematic Priority: 1.6.2 Sustainable Surface Transport

Publishable Executive Summary (M1-M48)

15.12.2010

Period covered: from 1.11.2006 to 30.10.2010
Start date of project: 1.11.2006

Date of preparation: 16.5.2011
Duration: 30+18 months

Project coordinator name: Tho Phan
Project coordinator organisation name: Wärtsilä Finland Oy

Revision: 1.0

Publishable executive summary

Project objectives

"Validation of Renewable Methanol Based Auxiliary Power System for Commercial Vessels" (METHAPU) aims to validate methanol technology on board a cargo vessel involved in international trade. In addition to that, another major aim is to innovate necessary technical justifications for the use of renewable methanol on board commercial vessels in order to support introduction of necessary regulations to allowing the use of methanol as a marine fuel. The specific components of the technology to be validated are methanol fuel bunkering, distribution and storage system and methanol consuming SOFC unit.

Contractors

The consortium is made up of experts in the field of fuel cell system integration, sustainable shipping, classification work and environmental assessment: Wärtsilä Finland Oy (coordinator), Lloyd's Register, Wallenius Marine, University of Genoa and Det Norske Veritas AS.

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Results achieved

The following achievements were reached and deliverables prepared during the project:

- Reassessed project plan was prepared immediately in the beginning of the project
- Marine Project Guide for SOFC installations
- Stakeholder analysis and requirements
- Definition of approval procedure
- Study on state-of-the-art of LCA
- Study on category rules for the product group (marine SOFC)
- Life cycle assessment for marine SOFC installation
- Test bench tested methanol reformer
- A 20kW prototype SOFC unit modified for marine conditions
- Factory acceptance test approved for the SOFC unit
- Factory acceptance test approved for the fuel cell unit and fuel cell room
- Factory acceptance test approved for the methanol tank container
- SOFC system installed onboard the ship Undine
- Harbor and Sea Acceptance test for SOFC installation, including concluded assessment of onboard SOFC system
- User manuals for SOFC system
- Ship procedures concerning SOFC system
- Test plan for field testing period
- Field testing period of 5 months including evaluation of results
- Introduction and training package for main users and ship crew
- General review of design for marine SOFC installation

Project website: www.methapu.eu, www.methapu.com

1 Project objectives and major achievements

General project objectives

The objectives of the project were:

1. Introduction of renewable fuel on board in support of the wider use of sustainable fuels in the marine transportation sector through research activities
2. Validate marine compatible methanol running solid oxide fuel cell technology
3. Innovate necessary technical justifications for the use of methanol on board cargo vessels involved in international trade in order to support the introduction of necessary regulations to allowing the use of methanol as a marine fuel
4. Facilitate future research activities on larger marine compatible SOFC units and methanol based economy
5. Assess short-term and long-term environmental impacts of the application

Current marine research projects focus on the use of fossil fuels, such as natural gas, and not on renewable fuel like methanol. This research project tackled the technological issues but also the regulatory challenges concerning the use of methanol, a fuel currently not permitted, as a fuel on board. Even though the validation was done with a 20kW test unit, the activities were devised to facilitate future research activities on larger SOFC units, on greener marine vessels and on more sustainable economy.

This project aimed at proving that the renewable methanol is a good fuel of choice for seaborne vessels utilising fuel cells, and that SOFC is a good fuel cell technology for seaborne vessels. To the extent possible within the project, the formulation of the Rules and Regulations for the use of methanol as fuel on board was facilitated. The project aimed to study and validate the SOFC technology in real marine conditions. In addition, research on the life cycle cost of the renewable methanol based marine compatible SOFC system on board a marine vessel was performed. The project was seen as to enable future research on the wider use of methanol in society, and on larger marine compatible SOFC units.

The results of the project could have provided some impulse to facilitate future research activities on greener marine transportation and on larger SOFC systems utilising sustainable fuels

Relevance of the objectives

Based on the description of the objectives of the project, the particular objective in the Sustainable Surface Transport Priority that matches with the project's objectives was the objective number one "New technologies and concepts for all surface transport modes (road, rail and waterborne)".

In actual, SOFC is not a new technology, but its use to generate auxiliary power for seaborne vessel is a new concept that needs to be validated. Furthermore, to use renewable methanol on board is a ground-breaking action, but that fitted well with the research domain 1.4 of the objective number one since:

- methanol is a renewable and alternative fuel
- methanol is a clean fuel and available around the world and in large quantities

- using methanol on board requires new bunkering, storage and distribution systems
- SOFC is a clean and efficient technology for propulsion and power generation on board

Furthermore, by enabling the future development of larger SOFC units for marine applications this research project contributed to the European Union's objective of sustainable use of marine resources while also improving the competitiveness of the European marine industry. The Consortium of this project was made of a world-class fuel cell developer and instances rated as to be among the most influential players in the European marine industry.

Links to other European research activities

The results of this project will be available to future FP7 projects focusing on sustainable marine transportation in which the use of sustainable fuels, such as methanol, and larger fuel cell systems would be the key points.

Dissemination

The consortium aimed to share the knowledge on the use of sustainable fuel and fuel cells in marine vessels to the wider marine industry, in particular stakeholders in marine power generation, marine operations, by e.g. presentations and article in congresses, conferences, organising workshops and to the wider community through publishing information on our website and a leaflet. The dissemination work was performed on a wide front as possible with the available resources.

Main achievements in the project

WP1, the reassessment of the project plan, was delivered timely in the beginning of the project to support the implementation of the project.

For WP2, the marine modification of the 250 kW unit, the scope for the Project Guide-document was changed as the project proceeded. The scope was shifted to cover the prototype SOFC-unit as this was seen to give the most benefit to the project. The deliverable, Project Guide for marine SOFC units, was prepared by end of the project.

WP3, the safety and reliability study, was carried out for especially the 20 kW prototype SOFC unit, in order to support the installation and test run onboard the ship. Stakeholder analysis was prepared. This analysis acted as input for the verification and validation process.

The assessment process concerning the prototype installation was defined for this project in particular as the existing Regulations and classification Rules alone could not as such be applied to the fuel cell installation. The product and process review was finalised with a presentation of the intended procedure for the Swedish Maritime Administration.

WP4, the life-cycle analysis (LCA) for the vessel using renewable based methanol fuel cells, was commenced with data transfer from the FCShip-project. In the subsequent task the objectives of the analysis were set and a State-of-the-Art -study prepared. The work continued with an inventory data collection, where field data was used as far as possible.
The LCA was carried out and shows clearly better environmental performance of a SOFC system in comparison with conventional engine solutions.

Product Category Rules were prepared, which define common calculation procedures to ensure that similar procedures are used for data collection and handling within the same product system.

Finally, the environmental impacts were compared to preliminary results, through data from the field test period of the prototype SOFC system. Due to limitations in the scalability of the test results, this data could not give a real picture of a generic marine SOFC in operation and therefore an alternative analysis method was applied.

In WP5, the design and build of a methanol reformer, the methanol reformer was built as a test module, to support testing in operation temperatures without the need to connect it to the actual SOFC system. The work for the testing included preparation of testing protocols. The testing was concluded with results supporting the suitability of the reformer for a 20 kW prototype unit.

The work in WP6, build a marine compatibility 20 kW SOFC unit, was supported by the build and operation of a 20 kW sister unit. This sister unit provided valuable feedback to the design and manufacturing of the project's 20 kW unit. The 20 kW unit was ready for Factory Acceptance Testing in April 2010 with the delivery of the methanol pump unit.

WP7, the testing of the marine SOFC unit, was commenced in sequence after WP6. The work comprised commissioning activities and finally the Factory Acceptance Testing carried out in Espoo with the main stakeholders in April 2010, which concluded the activities in WP8 as well.

WP 8, the acceptance of the 20 kW SOFC unit, was carried out closely together with WP7 and WP3 (definition of acceptance process). The work produced a submission map to facilitate the collation of relevant material for the acceptance and included dialogs between Wärtsilä and LR to support the design. The final validation of the SOFC unit was carried out in WP11 as part of the overall system.

In WP9, modification of a commercial vessel for methanol use, the ship Undine was chosen as the platform for the prototype SOFC testing. The ship was prepared with structural modifications to support the SOFC installation and the work was concluded in May 2010 with the installation of the Fuel cell room and Methanol tank.

WP10, the installation, integration and commissioning onboard of the 20 kW unit, delivered documentation for the installation as well as the actual installation and commissioning work onboard. During commissioning a Harbor Acceptance Test was conducted. The final deliverable from this workpackage was an updated Commissioning checklist for marine SOFC units.

WP11, the acceptance of the overall installation, produced a technology review of the complete fuel cell system onboard and comprised all preceding assessment phases as well as the Harbor Acceptance Test in Bremerhaven.

WP12, the operational safety assessment, delivered i) updated SOFC user manuals, ii) a crew introduction pamphlet, iii) a bunkering checklist and a follow-up report with revision remarks based on field testing phase experience by the crew.

WP13, field testing of the prototype SOFC unit, produced a testing plan with parameters identified relevant for the feedback. The testing period lasted 5 months, during which the ship travelled one turn around the world. The SOFC unit was operated on constant load. Field

maintenance support was carried a few times, both during sea voyage and harbour visits. The workpackage was concluded with the end of the project.

The work in WP14, review of the 250 kW design, produced generic design guidelines for methanol operating SOFC system and a study on heat recovery solutions for marine SOFC systems. The design guidelines were based from the experience of work in all phases of the project.

Table 2: Summary of the leaders and participants in the workpackages.

	Wärtsilä	**LR**	**Wallenius**	**Genoa**	**DNV**
WP1	leader	X	X	X	X
WP2	leader		X		
WP3	X	leader	X		
WP4	X		X	leader	X
WP5	leader				
WP6	leader				
WP7	leader				
WP8	X	leader			
WP9	X		leader		
WP10	leader		X		
WP11	X	leader	X		
WP12	X		X		leader
WP13	leader		X	X	X
WP14	leader			X	