SES6-CT-2004-502651

NEW H SHIP

Assimilation of Fuel Cells in maritime applications

SPECIFIC SUPPORT ACTION

FP6-2002-Energy-1

Publishable final activity report

Period covered: 01.02.2004-30.04.2005 **Date of preparation: 20.10.2005**

Start date of project: 01.02.2004 **Duration: 15 months**

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1 Introduction

This SSA project was established to ensure continued work on earlier national initiatives and EC projects concerning the use of hydrogen as fuel in marine applications. The foundations are the outcomes of projects like the FC-SHIP (ended in June 2004) and EURO-HYPORT (ended in July 2003). The New-H-Ship will bridge the gap in this field to assist in the creation of a new European Research Agenda. Jointly the outcome of all these projects will become the bases for the next research agenda in this field for the consortium members in all the projects

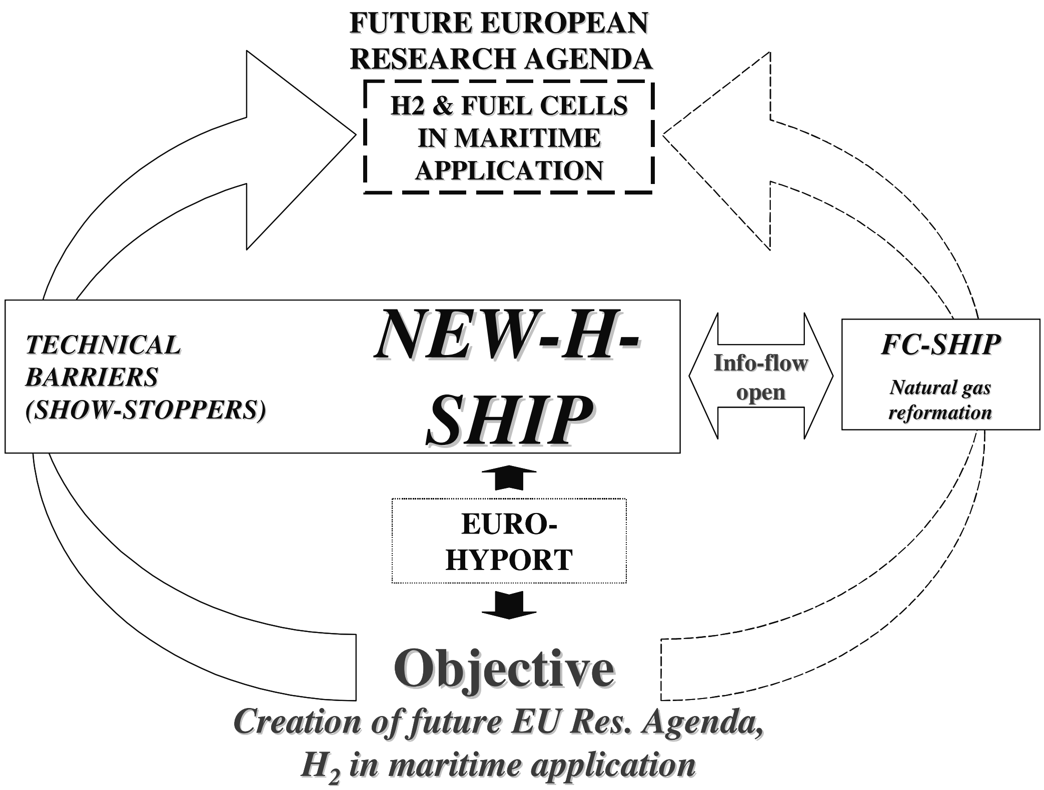

Figure 1: This figure shows the interconnection between current projects and the research gap that needs to be filled before creating a new European Research Agenda regarding using hydrogen and fuel cells in maritime applications

Taking fuel cells and hydrogen aboard a ship will demonstrate a fairly new technology in a completely new environment, which is both wet and salty and hard on electronic equipment. This offers new challenges related to the shipboard requirements. The aim of the project was to identify technical and operational obstacles related to the shipboard system- requirements and infrastructure for maritime fuels. As preparation for real demonstrations, the project suggests mitigating actions so that investments and the technology for using hydrogen on board will be feasible and secure.

Main goals

- Identification of technical barriers (showstoppers) for FC and H_2 on board ships
- Mapping the road to H_2 drive propulsion in ships and making recommendations for further Research and Development
- Creation of reference list of R&D activities regarding fuel cells and hydrogen in maritime applications
- The project will identify supporting European activities in the field of hydrogen and fuel cells in maritime applications and pre-screen potential partners

2 Participants list

The project consortium is a strong combination of ten organisations including manufacturing companies and research institutes, each a leading body in its field (hydrogen production, specific maritime research institutes, ship engine manufacturer, socio-economic research, etc). The advantage of this group of companies is that already there is co-operation between most of the partners in the projects in the same field. This gives the consortium a platform to learn to work together, and to harmonise the results from other projects adding the know-how from this project and in that sense creating a critical mass and maximising the outcome of the different projects and in that sense utilising resources already being used and maximising the results from them. With these organisations working together in the NEW-H-SHIP the project will have sufficient resources in the project and combining these results with other so that the next step in utilising fuel cells and hydrogen in maritime applications, as there will be a joint understanding between the different players on tackling these future concepts.

List of Participants

Participant name	**Participant short name**	**Country**
Icelandic New Energy.ltd	INE	Iceland
Fisheries Technological Forum	Fish Tec	Iceland
Marintek	MARINTEK	Norway
Det Norske Veritas	DNV	Norway
Germanischer Lloyds	GL	Germany
MTU Friedrichshafen	MTU	Germany
Delft University of Technology	DUT	Netherlands
Technological Institute of Iceland	Ice Tec	Icelandic
Fincantieri	F/C	Italy
University of Applied Science	UASHH	German

3 Methodology and execution of the project

The project was divided into 4 subtasks, each focused on one specific target.

1. The first task was to compile information from projects like FCSHIP, Euro Hyport and EQHHPP, including such as design specification and conceptual designs and make it available to the New H Ship project.

2. In the second task the information gathered through task 1, specifically including the conceptual designs developed, was handled for identification of project stoppers using acknowledged methods for structured workshops, including risk assessment. The responsible work task leader DNV organized a workshop to summaries partners approach and information. Supportive data (including information from MTU's yacht demonstration) and activity in workshops was provided by MTU
3. Task tree dealt with the identification of supporting European activities. This meant mapping of supporting R&D activities in Europe and by that forming an update of the R&D reference list created in the FC-SHIP project.
4. The fourth task is one of the most important ones. This task included pre-screening of potential partners and critical risk elements for a future H_2 fuelled ship demonstration project. Tasks 2 and 3 above provided the starting point for the evaluation of potential partners for the suitability for setting up a real demonstrator. Initial contacts were made to all groups trying to form a demonstration project at that time and the critical risk elements discussed for solutions. Big efforts were put into trying to find a common ground for a project proposal but unfortunately without success, mostly due to lack of commitment from the industry and/or lack of clear policy of the funding organizations towards H_2 fuelled ships. However part of the New H Ship group did participate in the EU proposal WHALE which was an Italian initiative offering other European partners to join in on a demonstration project in Venice, demonstrating a small passenger boat propelled with hydrogen. Unfortunately this proposal was not approved for funding by the EU.

4 Project product

The products of the project are in the form of reports. Four reports were made and the titles are listed in Table 1. Three of these reports are public but one is restricted to the project group and the commission, this is the list of pre-screened participants for the next steps.

Table 1: Deliverable of the New H Ship project

Deliverable name	Nature	Dissemination level
Reference list of R&D activities regarding fuel cells and hydrogen in maritime applications	R	PU
Recommendations for further Research and Development.	R	PU
Feasibility for shipboard use of hydrogen and fuel cells	R	PU
List of pre-screened participants for the next step, including evaluation of resources	R	RE

5 The projects publishable results, summary of conclusions

5.1 Technology status and marine project experience

The update of information from FC-SHIP and other projects concerning maturity, performance, durability etc. reflect promising steps forward. Though the announcements mainly of the car industry from the 90s have not yet been met entirely, today there seem to be quite a number of fuel cell applications waiting in the wings to enter the market both on the road and in house. Though even in highly funded projects like SECA, today's work is addressing, solving and developing a great many of detail improvements, which obviously takes it's time.

Fuel processing as a major issue for any vessels sailing autonomously for a longer time/distance is on the agenda of some developers. Concerning this task, the development of high temperature PEM MEAs comprising a relevant CO-tolerance are of great interest.

Concerning off-shore applications, developments still appear to be rather limited, which of course may also be caused by issues of nondisclosure as far as military applications are concerned. The very ambitious 625-kW-Ship Service Fuel Cell Program seems to stagnate–possibly due to a too large step to be accomplished from current Hydrogen run 200 kW transport applications to a mobile Diesel fuelled 625 kW MCFC.

Considering other marine fuel cell and hydrogen related programs it appears quite clear that even though developments are ongoing, the jump to real-life demonstrator projects is hampered by various factors, with perhaps the most important one being the large financial resources required for the necessary development work.

From the point of availability and maturity of the technology, a sensible next step could be the transfer of today's mobile PEM technology to a vessel operating in a limited range to learn about its behaviour under special environmental conditions like salinity, motion and cycling. Adapting APU technologies e.g. based on SOFC technology could also be transferred to seagoing vessels early for the same reasons, though these will serve only for a small part of a ships auxiliary load.

It should be noted that in order to bypass the hydrogen infrastructure and storage issues there are other fuel options than hydrogen possible (e.g. Methanol, LNG, diesel) for fuel cell applications, and that these solutions may act as bridging projects towards future pure hydrogen solutions.

Taking the above into consideration it seems evident that direct hydrogen as a primary fuel in larger vessels might not be the correct start for a demonstrator project. The hydrogen storage requirements of larger vessels indicate that the immediate focus should rather be on smaller vessels when developing pure hydrogen solutions. It is evident that boats with engines smaller than 1000 kW may be suitable since hydrogen storage options can be designed for use in these smaller vessels. The project believes that one good option for the next step would be to install a hydrogen fuel cell engine in a small boat for main propulsion and demonstrate the viability of such a project. This would constitute a proof of concept project, possibly for operation in the harsh environment of the Atlantic Ocean. It would also be an evaluation of the hydrogen shore infrastructure required for such a project. Nevertheless the conclusion from FCSHIP that reformer technology and high temperature fuel cell development including demonstration of this technology still remains valid.

5.2 Barriers to commercialization

The most significant conclusion regarding the barriers to commercialisation can be summarised as follows;

- Hydrogen storage technology options presently limit the types of feasible hydrogen powered vessels to small and low powered applications. Barring unforeseen technological breakthroughs this is likely to remain the case for quite some time. (But other fuel types can be utilized as bridging technologies towards pure hydrogen applications).
- There is an urgent need for genuine and relevant demonstrator projects showcasing marine hydrogen and fuel cell technology, both to build knowledge/-experience, and to create market and public confidence in the technology
- There is an urgent need for coordinated efforts on regulations, codes and standards, both for shore and marine hydrogen applications

5.3 Next step recommendations

As is identified in this project there are no showstoppers that were discovered. The main issues regarding using hydrogen in ships seams to be connected to storage of H_2 on board the larger vessels (specifically those who are at sea for weeks or months). However smaller vessels and also those ships that come frequently into harbour can use hydrogen for main propulsion (larger ferries might start with APU systems).

Storage of hydrogen is therefore ranked as one of the key elements for research. Currently there are many such projects ongoing and results from them will be beneficial for maritime applications also. However it should be pointed out that there is not a very high priority in projects on chemical storage, for example sodium borohydride $NaBH_4$, which could be a good application for marine applications.

Connected to storage, but potentially different from conventional transport applications is the **availability and distribution of hydrogen for marine applications**. The distribution network for marine application is likely to differ from the future hydrogen distribution network for other transport applications. Also currently there is a very limited H_2 market and the distribution of the energy carrier must match the current/future vessel trade. In this sense governmental incentives could jump-start both market and investment.

Practical design and operation is missing. Already there have been almost none demonstrations of marine applications, but the one that is described in other documents of this project is the yacht operation on the Lake Constance. That showed that the technology worked well for such an application but unfortunately a follow up was not successful. It is of absolute necessity to start projects which involve practical designs and operation under real life conditions to verify results from this project and other similar ones.

Closely connected to a practical design and operation are **regulations, codes and standards (RCS)**. Currently they are incomplete and non-harmonised. There is a lot of work currently being done on RCS (global cooperation) and it is important that in all international cooperation for RCS there should be a reference to marine applications of hydrogen. Work done in all aspects of the RCS will benefit hydrogen use in marine applications but direct participation in that work should be done in connections with the classification societies for ships, etc.

At this stage in the general development of hydrogen technologies **investment costs and operation** will be higher than for conventional ships. Already considerable measures have been taken by both the EU and national governments to initiate programs involving vehicles and buses. Similar incentives are necessary for marine applications if such projects are to become a reality in the near future. In this sense financial incentives may be a necessary tool for the initial steps. Fighting increased greenhouse emissions is a global issue and all emissions contribute to that, though the visibility from marine activities are lower they have the same impact. In this regard government policy is in many cases missing. Here it is not only the EU policy but also national initiatives, specifically from nations that rely heavily on marine activities, fishing and transport.

Other issues are also important, for example the *vessel power demand* which is different from vehicles or buses. Also with lack of policy and incentives the *drive for a vessel owner is very low* to change to a different fuel. Currently there is no “carrot” for the vessel owner/operator. Fuel is not readily available, special extra training might be needed, regulations are not ready, other societal barriers might have to be overcome, higher risk, etc. All these factors (barriers) needed to be reduced to increase the interest for the vessel owner/operator and also to encourage shipyards to take the initial step to design and build the first vessels for demonstration purposes to verify that the technology is fully valid for use in marine applications.

Already considerable know-how has been generated regarding use of hydrogen in the transport sector. Specifically the projects of CUTE and ECTOS (bus demonstration) should be identified in that regard. Valuable learning has been generated in those two projects and that can strongly benefit projects which take the technology out to sea. **However it is of utmost importance to set up similar projects as the CUTE/ECTOS are in the marine sector with multi stakeholder participation to learn and to overcome most of the potential barriers mentioned here above**.