

e4ships

Fuel Cells in Maritime Applications

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Project motivation

- ≡ *e4ships – fuel cell in maritime applications* is a joint effort of leading German yards, ship operators, manufacturers of fuel cells, equipment suppliers and classification societies
- ≡ The association is working on a joint industry project, which is partly financed by public funds
- ≡ The common interest is in the use of fuel cell technologies for environmentally friendly energy supply systems on ships
- ≡ Midterm usage in market applications



Partner as per December 2016



Structure of the project

≡ e4ships = 3 sub-projects:

≡ **Toplaterne:**

„Synergy-module“

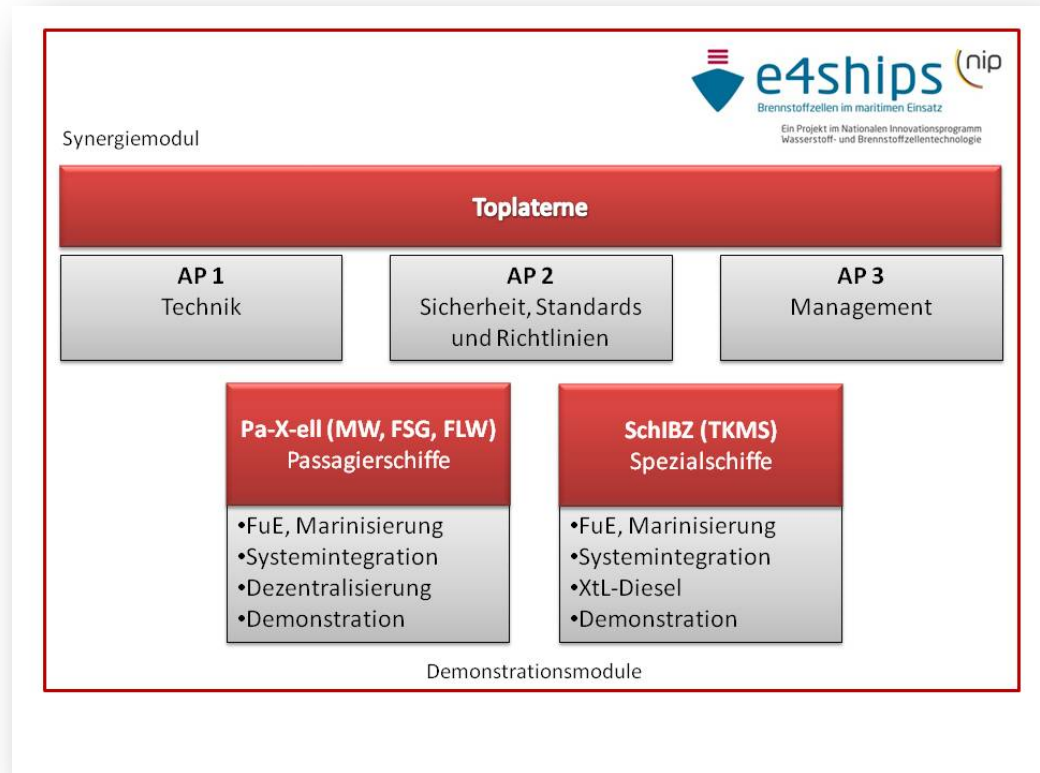
ecological, technical and
economical questions

≡ **Pa-X-ell:**

Passenger vessels

≡ **SchIBZ:**

Multi purpose ships



Project content

- ≡ Emissions of seagoing vessels in harbours need to be decreased strongly in order to meet stricter regulations (SECA, ECA)
- ≡ Main focus: supply of auxiliary power units (APUs)
- ≡ In e4ships high-temperature fuel cells (SOFC and PEM) for APUs are tested in lab as well as operation on seagoing ships
- ≡ The advantages of generating power via fuel cells onboard ships are twofold:
 - ≡ the emission of toxic pollutants is reduced and the efficiency of the facilities is improved
 - ≡ fuel cells are an attractive and efficient alternative to conventional ship aggregates and can contribute considerably to decreasing harmful emissions
- ≡ Technical integration of systems in different types of vessels and development of consistent technical standards



About the project

- ≡ Changing framework conditions for shipping: environmental law limits emission levels, e.g. in emission control areas (ECA)
- ≡ Cooperation of leading German shipyards, shipping companies, manufacturers of fuel cells and classification societies
- ≡ The total budget for “lighthouse project”: 39 million €
- ≡ Project duration: 01.04.2009 - 31.12.2016, preparation for next phase underway
- ≡ Project of the National Innovation Programme for Hydrogen and Fuel Cell Technology (NIP), funded by the Federal Ministry of Transport and Digital Infrastructure (BMVI)



Project synergy module (Toplaterne)

- ≡ In addition to working on solving specific technical aspects in dedicated individual projects, a common exercise – the synergy module – is dealing with issues of climate protection, economics of using fuel cell technology, technical standards pertinent to safety and strategy for the market introduction as well as codes and standards including the regulatory framework (IMO)
- ≡ This is addressing also additional novel fuels like ultra-low sulphur diesel or natural gas
- ≡ The specific objectives of the synergy module are:
 - ≡ Benchmark of existing energy supply systems with novel fuel cell based systems which are developed in this joint industry project. Benchmark parameters include sustainability and energy efficiency
 - ≡ Identification of investment and operating cost of fuel cell systems as a basis identification of potential for future optimization
 - ≡ Definition of technical use case and further roadmaps with respect to restrictions on space, weight and power demand on seagoing ships
 - ≡ Adaptation of IMO's IGF-code to support market introduction



Demonstration project Pa-X-ell

Pa-X-ell

- ≡ HT-PEM fuel cells on a passenger ship tested
- ≡ HT-PEM fuel cell with methanol
- ≡ Internal methanol reformer for hydrogen production
- ≡ Modular and standardized systems setup
- ≡ Module: 5 kW – Rack 30 kW
- ≡ Adaption of the systems for maritime utilization
- ≡ Liquid cooled



- ≡ Partners:
Flensburger Schiffbau Gesellschaft,
Friedrich Lürssen Werft, Det Norske Veritas – Germanischer Lloyd, Serenergy,
Deutsches Zentrum für Luft- und Raumfahrt, MEYER WERFT, INVEN Engineering



Demonstration project Pa-X-ell onboard ferry MS Mariella

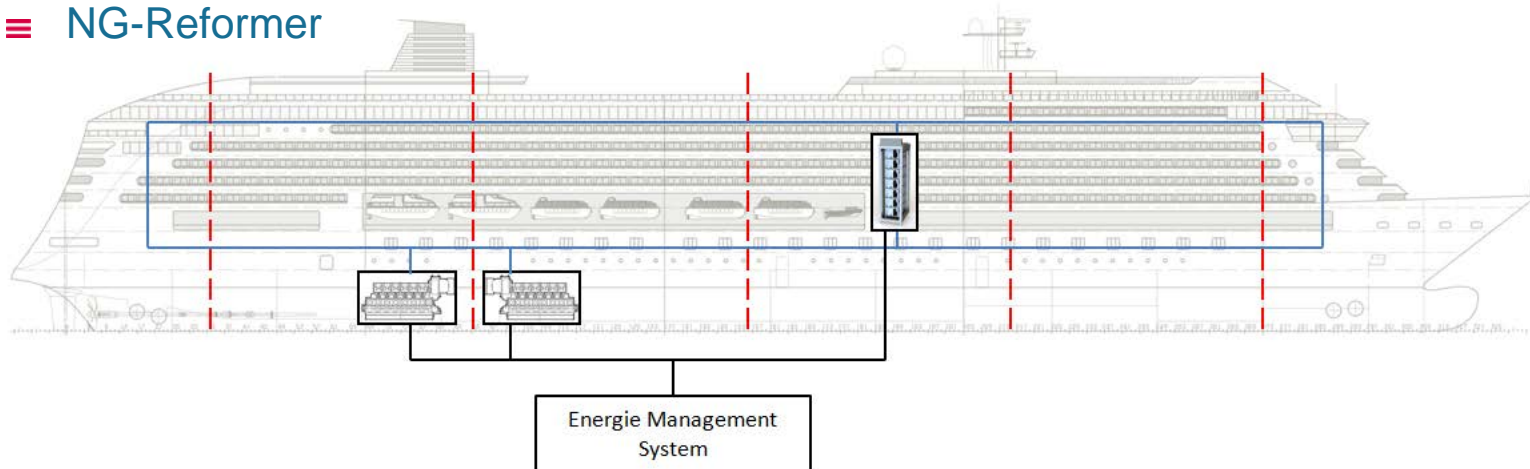
Pa-X-ell

- ≡ Installation of the fuel cell system onboard of the ferry MS Mariella
- ≡ Methanol supply and storage
- ≡ Mixing unit for generation of methanol-water-mixture
- ≡ Input of electrical and thermal energy to network onboard



Outlook Pa-X-ell 2

- ≡ Further development and optimization of the systems
 - ≡ Increase in performance (up to 20 kW per module, today 5 kW)
 - ≡ Increase of lifetime (>20.000 h)
 - ≡ NG-Reformer



- ≡ Longtime testing of existing demonstrations
- ≡ Development of decentralized energy network and hybrid systems
 - ≡ Mega-Yacht: Demonstrator at pier and onboard (hybrid system)
 - ≡ Cruise ship: Demonstrator for supply of one fire zone
- ≡ Further strong involvement in development of rules and regulations (IMO as well as European)

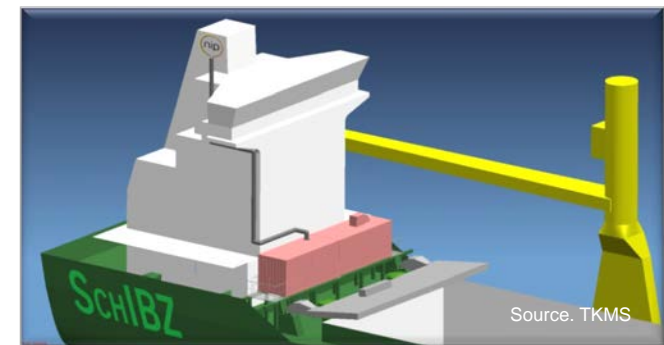
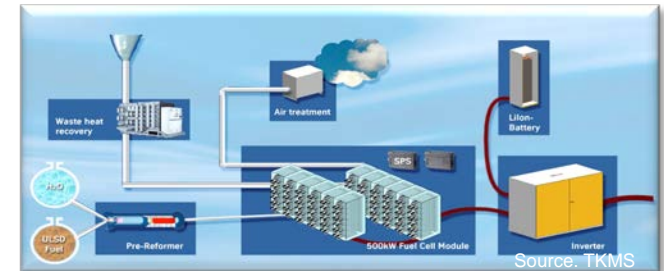


Demonstration Project SchIBZ

SchIBZ

- ≡ High-temperature fuel cell for seagoing vessels developed and manufactured
- ≡ SOFC fuelled with Diesel oil (max. 15 ppm S)
- ≡ Reformation of Diesel
- ≡ Operations onboard MS FORESTER beginning in 2017 until end-of-life of fuel cells
- ≡ Supply of 25 to 50 % of the power demand
- ≡ Buffering of load fluctuations
- ≡ Addition of heat recovery
- ≡ Enhancement for distributed networks
- ≡ Integration with DC-grid

- ≡ Partners:
Öl-Wärme-Institut, DNV GL, Leibniz Universität Hannover, M & P, Rörd-Braren Bereederungs-GmbH, Sunfire



Further demonstration project RiverCell

RiverCell

- ≡ Design of a hybrid power plant for a river cruise vessel
- ≡ Feasibility of downswing of a ship with batteries and fuel cells only, driving up-hill with the support of engines
- ≡ Silent operation of the ships with fuel cells at berth and increase efficiency of fuel cell systems
- ≡ Blueprint for other ship types e.g. ferries
- ≡ European regulations for permission
- ≡ Partners:
Flensburger Schiffbau Gesellschaft, Det Norske Veritas – Germanischer Lloyd, Serenergy, Viking Technical, MEYER WERFT, NEPTUN WERFT, hySOLUTIONS, Fischer eco solutions, HADAG



Fuel Cells and the IMO IGF Code

International Code of safety for ships using gases and other low-flashpoint fuels (IGF CODE))

- ≡ With FC systems an environmentally friendly, high efficient technology becomes available
- ≡ IMO IGF Code introduces new, clean, environmentally friendly fuels for shipping
- ≡ e4ships provides input for the IMO rule development of alternative fuels since 2009
- ≡ Reliable international regulatory framework is needed ensuring a level playing field and planning reliability



Continuous work on IMO regulations needed

- ≡ 2009 to 2015 – development of the IGF Code for LNG and CNG as fuel
- ≡ 2004/2019 develop the IMO Interim Guidelines for LNG as fuel (IMO MSC.285(86))
- ≡ 2009/2015 first stage of the development of IMO IGF-Code: International code of safety for ships using gases or other low-flashpoint fuels (adopted by MSC 95 on 12th of June 2015, in force January 2017)
- ≡ FC systems are allowed “in principle” by the IGF Code
- ≡ More detailed requirements needed
- ≡ Work on methanol and low flashpoint diesel is ongoing/proposed
- ≡ Requirements for distributed power networks are needed

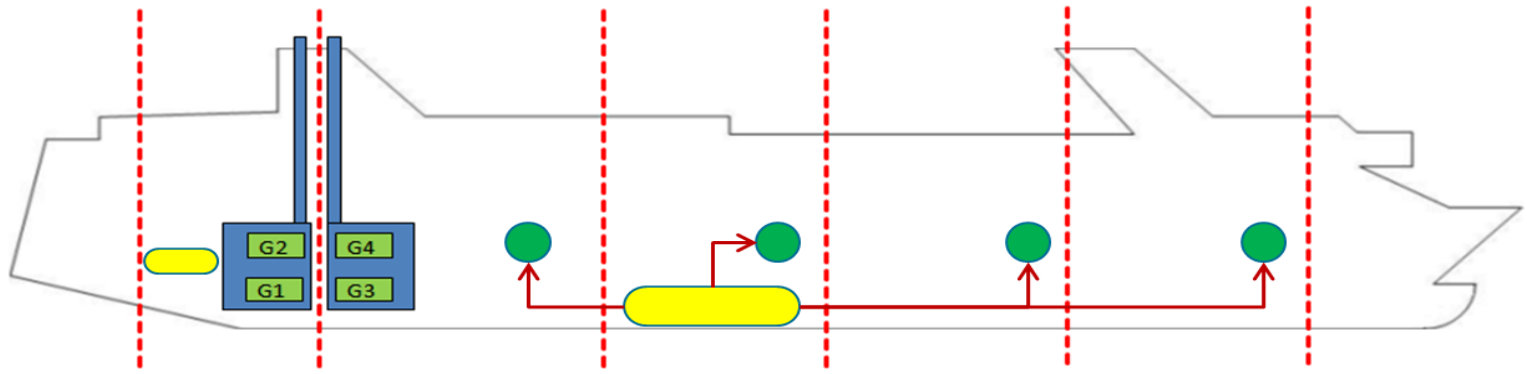


Next steps for IMO rule development

- Phase 2 and 3 -

Regulatory aims for e4ships 2:

- ≡ Integration of FC systems and relevant alternative fuels into MARPOL Annex VI – Energy Efficiency Design Index (EEDI),
 - ≡ Methanol, low flashpoint diesel, hydrogen
- ≡ SOLAS-requirements for distributed power supply



What can policy do to promote alternative fuels and FC technology?

- ≡ Support of new technologies by research and development projects in Germany and worldwide
- ≡ Give clear boundary conditions for the reductions of emissions (MARPOL Annex VI, EU and IMO Sulphur requirements, ZKR)
- ≡ Support innovations by IMO work on challenging and innovative safety requirements for new buildings and retrofitting of ships (SOLAS (IGF Code))
- ≡ Support the introduction of technology by support of pilot projects, support of investments into “Green Shipping“
- ≡ Enhance permission framework



e4ships - Fuel Cells In Maritime Applications

Thank you!

