Clean Energy

Zero emissions: hydrogen as a fuel is also gaining ground in connection with ships – yet so far only to a lesser extent. For larger vessels, gas already provides an environment-friendly and cost-effective alternative

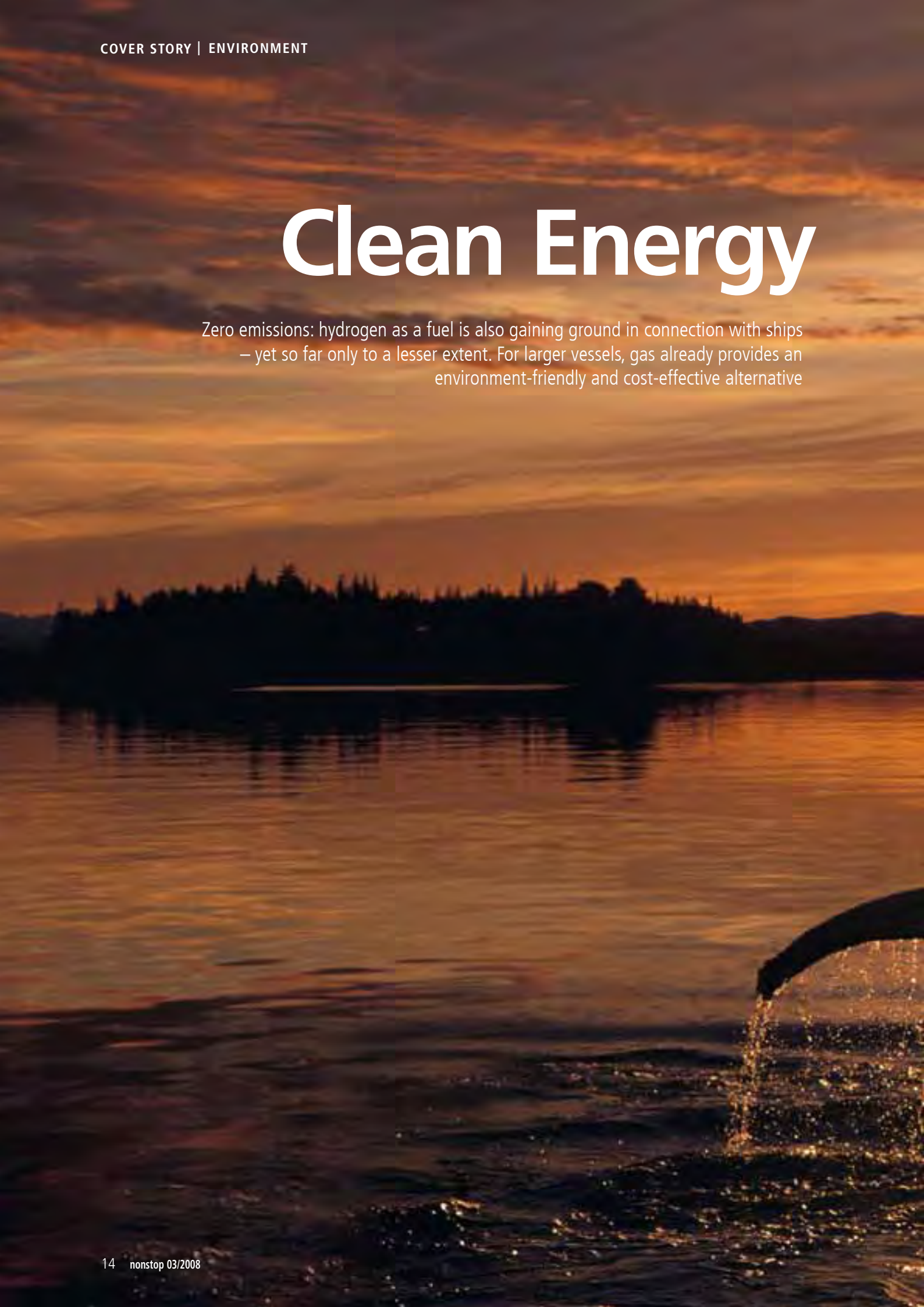


Photo: Corbis

No CO_2, sulphur dioxide or noise emissions – soon many seagoing vessels will be able to operate on such environmentally friendly terms. This is made possible by the use of hydrogen propulsion systems. With its high energy content and low environmental impact during the use, H_2 offers not only an energy-efficient alternative to conventional fuels, but, owing to high oil prices, also an economic one.

Worldwide efforts to limit CO_2 emissions are beginning to have an impact. Gas, which has a low carbon content compared to mineral oils, is becoming increasingly popular as a marine fuel. An additional factor is the establishment of sulphur emission control areas (SECAs) in the North and Baltic Sea and the English Channel. From 2015 the percentage of sulphur in marine fuels will have to be reduced from 1.5 per cent to 0.1 per cent. This regulation will come into effect in California in July 2009, and it already applies there for auxiliary engines. The timing is perfect: investments that would have been seen as uneconomical just a few years ago are now economically viable.

"Alsterwasser" Under Way

In Hamburg the idea of an emission-free ship is a reality already. "FCS Alsterwasser" was recently launched and now sails on the river Alster in Hamburg's city centre. There is room for approximately 100 passengers on this eco-friendly tour boat. According to Jens Wrage, the former managing director of the shipping company ATG, "This is the first passenger ship of its size anywhere in the world to run on fuel cells." The fuel used is pure hydrogen. Each of the two fuel-cell modules has a power output of 48 kW (64 hp) – the same amount of power required by a bus. The engine →

Photo: Elding

SILENT. On the "Elding I", the hydrogen auxiliary power unit replaces the diesel – to the delight of the whales.

The Projects

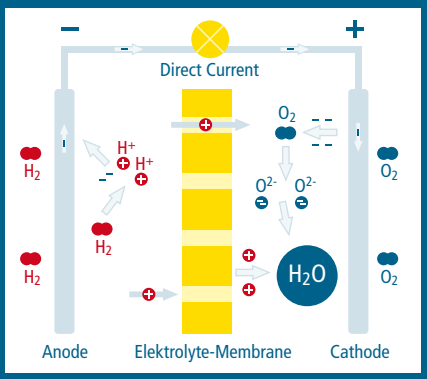
Reykjavík: Elding I

In April 2008 the "Elding I" was inaugurated with a first test trip. The whale-watching ship received a hydrogen auxiliary power unit in addition to the regular diesel engine. With its two viewing levels and the third deck, the boat allows all passengers to watch the whales in their natural habitats. The intention is to shut down the main engine when the boat has met with whales out at sea and offer the guests to see and hear the animals and to allow an even closer encounter with them.

The experience, owner Vignir Sigursveinsson said, had been marred in the past by the rumble of the diesel auxiliary engine below. "When we have the hydrogen engine, the boat will be completely soundless, which will make it a great experience of seeing the whales in their natural habitat," said Sigursveinsson.

"Elding I", originally built in Iceland as a rescue ship, is a 125-tonne cruiser with a capacity to carry 150 passengers. It is part of the "SMART-H_2" project which is a demonstration project testing various types of hydrogen-fuelled equipment for vehicles and vessels. SMART-H_2 began in March 2007 and will extend until 2010.

GL's experts carried out the necessary studies and research to certify the fuel-cell system installed on board "Elding I". The certification comprises the assessment of the safety system, fuel-cell components, and electrical equipment, as well as pressure testing and explosion protection. The ship's auxiliary power unit (APU) consists of a fuel-cell operated by compressed hydrogen providing electricity for the ship operation. In April, the certification was issued. "This project demonstrates for the first time the use of fuel cell systems on a commercial seagoing vessels," said Dr Würsig.



Fuel-Cell Technology

Just like a battery, a fuel cell is a device that directly converts chemical energy, for example from hydrogen and oxygen, into electrical energy. Hydrogen and oxygen are brought into contact with electrodes. They then bond in a process of reverse electrolysis, "cold combustion", to form water. This creates a direct conversion of the chemical energy to electrical energy. Because the conversion is direct, the electrical efficiency of a hydrogen fuel cell is very high. It can be up to 60 per cent. Most fuel cells use the oxygen available in the ambient air, so, of the two elements required for the reaction, only hydrogen must be carried as a fuel.

The principle of the fuel cell was discovered in 1839 by Friedrich Schönbein and Sir William Robert Grove.

→ was developed by Proton Motor for the EU research project Zemships and delivered by articulated lorry to the SSB Shipyard in Oorthkaten near Hamburg in mid-July.

The six fuel-cell stacks are pooled as an assembly of the fuel-cell system in an aerated capsule, completed with the control panel, air compressor, sound absorbers and cooling system. The hybrid system consists of fuel cell and battery. The greatest power output is required when the boat docks and casts off. During the voyage the battery is recharged by the fuel-cell engine. This system can therefore be optimally adapted to the vessel's load profile. The fuel cells are supplied with 350 bar from twelve pressure tanks. Refuelling takes place at a hydrogen refuelling station in Barmbek, a district of Hamburg.

For many years, the power output of fuel cells was so low that they "only" supplied energy for the on-board electrical devices, but not for the propulsion system. This is no longer the case. According to Dr Gerd Würsig, the fuel-cell expert at Germanischer Lloyd, "Fuel cells now deliver from ten to 250 kilowatts (kW)." The more the better: One of the findings of the 2004 fuel-cell feasibility study FCSHIP was that modules with an available power capacity of approximately 500 kW are needed for marine applications. "That's enough to drive small ferries and sports boats," says Dr Würsig. However, the energy requirement of larger ferries, tug boats and port authority vessels is at least one megawatt. The power capacities that will be available in the fore-

ECO-STEAMER. On the tour boat "Alsterwasser" (photo: the cockpit) the fuel-cell engine guarantees environment-friendly transport of passengers.

Amsterdam: Fuel-Cell Boat

The fuel-cell boat is expected to sail on the canals of Amsterdam from early 2009. A Dutch consortium composed of the companies Alewijnse, Integral, Linde Gas, Marine Service North and the shipping company Lovers is currently developing a hydrogen-powered boat for canal tours. Like "MS Alsterwasser" in Hamburg, this boat will carry approximately. 100 passengers. It is being built at the Bodewes Shipyard in Hasselt, Netherlands.

This vessel will be in operation for up to twelve hours a day. 2,000-kilogramme batteries will act as a back-up to ensure peak performance. The fuel-cell system is undergoing certification from Germanischer Lloyd. Even the fuel is to be produced in an environmentally friendly way. Electricity from the Shell-Nuon/Q7 wind park in the North Sea will be used in the electrolysis process that produces hydrogen. The first commercial client has already signed on.

Photos: Fuel Cell Boat b.v.

Shell Amsterdam will use the fuel-cell boat to transport 600 of its employees daily to and from their place of work on the opposite bank of Lake Ij – between Amsterdam Central Station and Shell's new technology centre (NTC). The project is being co-funded by the Dutch Ministry of Economic Affairs.

Photo: H2 Yacht

Hamburg: H_2Yacht

Even the traditional "Tuckerboot" or launch is being fitted with a hybrid motor. In normal operation the boat is powered by electricity generated in the fuel cells. The buffer batteries mitigate heavy load changes. "The H_2Yacht 675 is intended for mass production and would thereby be the first commercial sports boat with fuel-cell propulsion," says Dr. Walter Pelka, Managing Director at H_2 Yacht. With a length of 6.75 metres and design category C it is intended for inland waterways and coastal voyages. The boat can accommodate eight passengers.

The hull is being manufactured from fibreglass-reinforced plastic at a Hamburg boatyard, while the 2 × 1.2 kW PEM fuel cells were developed by the Centre for Solar Energy and Hydrogen Research Baden-Württemberg (ZSW). Hydrogen is stored on board in metal hydrid containers. The power capacity can be adjusted to the route of the boat and the refuelling options. This boat and its propulsion system are also undergoing certification by Germanischer Lloyd.

Photo: H2 Yacht

Photo: Zebotec

Lake Constance: COBALT 233 ZET

In November 2005 the first fuel-cell sports boat was unveiled by zebotec. Swiss company Brunnert-Grimm and South German zebotec are currently fitting a mass-produced sports boat with a hybrid propulsion system composed of electrical engine, batteries and fuel cells. This 2 x 12-kW propulsion system is undergoing certification by Germanischer Lloyd.

seeable future are still too low. That's why the use of fuel cells in marine navigation will initially be limited to auxiliary functions. Dr Gerd Würsig predicts: "The first fuel-cell applications in marine vessels beyond those of a pilot or demonstrational character won't appear until after 2015."

GL has certified the fuel-cell system of "FCS Alsterwasser" according to its "Guidelines for the Use of Fuel-Cell Systems on Board of Ships and Boats" (VI-3-11). Since the mid-1980s GL has been involved in developing ships, storage and transfer facilities for hydrogen. As the world's first classification society, it has developed its own guidelines for the use of fuel cells in watercraft. These not only cover fuel cells and fuel systems but also standards for the materials used, ventilation systems, firefighting equipment, explosion protection and other safety systems. They also contain precise guidelines on testing the fuel-cell system.

On Board, It's Safety First

Germanischer Lloyd certified the fuel-cell drive of the open passenger ship "Hydra" in 2000. Three years later it certified the "CoolCell" fuel-cell propulsion system developed by MTU Friedrichshafen for the yacht "No. 1". Other fuel-cell projects include the 160-kW demonstration model for sea-going vessels that was developed together with HDW Fuel-Cell Systems (HFCS) and the unmanned research submarine "DeepC". Together with several renowned part- →

Gas as a Marine Fuel

Photo: BPS

EXCEPTION. LNG tankers are allowed to use "boil-off gas" that is produced during the transport.

Compared to oil, natural gas has clear environmental advantages – high efficiency and good environmental properties. Until now the use of gas as a marine fuel in international shipping was forbidden by the International Maritime Organization (IMO) for safety reasons. According to SOLAS, only fuels with a flashpoint of over 60 °C may be used on vessels. That is why kerosene is also prohibited. So far the one exception to this rule has been LNG tankers, which are allowed to burn the "burn-off gas" that is produced for technical reasons.

"Gas is not dangerous per se," explains Dr Gerd Würsig from Germanischer Lloyd. The IMO has also come around to this point of view. Its sub-committee on Bulk Liquids and Gases (BLG) is currently working on provisional guidelines to meet present demands for safety standards in the use of natural gas as a marine fuel. The sub-committee is expected to submit these guidelines to the Marine Safety Committee (MSC) for approval in 2009. If all goes well, from 2010 there will be a legal basis for using natural gas as a marine fuel in combination with combustion engines in international shipping. "This will lead to greater confidence in planning," comments Dr Würsig, who is also a member of the BLG working group.

It is vital to consider the specific properties of gas when planning to use it as a marine fuel. According to Dr Würsig, "gaseous fuels are difficult to transport." Tanks for liquefied gases or pressure tanks are needed Instead of regular fuel tanks. In any case, the volume required is greater – a ship would not get far on one pressure-tank load. Extensive infrastructure for fuel supply is not yet in place. It's therefore obvious where the best place would be to start using gas – on ferries or liner feeder vessels with short voyages.

The demand is enormous. Emission reduction requirements in Europe have increased once again following the MEPC meeting in April 2008. A study conducted by GL showed that a gas-powered vessel would not only reduce emissions but costs as well. Under certain conditions a container feeder with 1,500 TEU, 8,750 kW and a speed of 16 knots could actually be more economical than a conventional freighter.

The experts from GL took the following parameters into account in their calculations: higher costs of 1.5 per cent for fuel with a lower sulphur content, a CO_2 levy of US$ 25 per tonne, income reduction due to the loss of approximately 50 container slots because the gas tanks require considerably greater volume, and investment costs for the gas tanks. The surprising result of their calculations was that after 15 years of operation the cumulative costs of a gas-powered propulsion system would be about one million US dollars lower than those of a conventional propulsion system. The general rule they established was that the higher oil prices rise and the higher the actual CO_2 levy is, the greater will be the cost savings. GL is currently working out the operative details of this model in a pilot project together with partners.

GL's Head of Division Strategic Research and Development, Dr. Pierre C. Sames, is convinced: "Gas will definitely be used as a marine fuel. This will make a major contribution to optimal fuel usage and reduction of CO_2 emissions."

Photo: Gaitzsch

CONTAINER FEEDER. Gas as a frugal fuel.

GAS OPERATED FEEDER	
Spec. cons.:	7,550 kJ/kWh
Fuel costs:	$ 14.2/GJ
Consumption/voyage:	219 t
LSF surcharge:	0
CO_2 emissions/voyage:	642 t
Total costs/voyage:	$ 171,000
Loss of income:	$ 200,000/year

CONVENTIONAL FEEDER	
Spec. cons.:	0.18 kg/kWh
Fuel costs:	$ 600/t
Consumtion/voyage:	260 t
LSF surcharge:	$ 30/t
CO_2 emissions/voyage:	809 t
Total costs/voyage:	$ 184,000
Loss of income:	0

Advantage of gas: one million dollars*

* Basis: 15 operating years

→ ners, GL has been working for years to extend the benefits of this technology to additional applications. For example Airbus is also involved in joint projects with GL to develop safety standards for fuel-cell systems on board aircraft.

Prototype Ready for Mass Production

The Zemships project cost approximately five million euros, which included the ship, its drive system and fuelling station. Just the fuel cell with battery and tanks alone cost two million euros. "If you were to buy the system now it would only cost 300,000 euros," explains Anno Mertens, Project Manager at the fuel-cell expert Proton Motor.

A comparable diesel motor costs between 60,000 euros and 70,000 euros, but it is important to remember that these have been in mass production for much longer. At present, mass production of fuel cells has not yet begun. "The application gives you access to industrial production. Once you have achieved that, the fuel cell is commercially competitive", Mertens says. ■ SNB

UPCOMING EVENTS

22–23 October 2008
International Conference and Trade Fair on Hydrogen and Fuel-Cell Technologies
CCH – Congress Center Hamburg
Lecture on "Approval of Marine Hydrogen Applications" by Finn Vogler, Germanischer Lloyd, on 23 October at 3:00 p.m.

23 October 2008
Zemships Conference
CCH – Congress Center Hamburg; Dr Würsig of Germanischer Lloyd will chair the afternoon lectures. **Lecture on "Safety and Classification of Fuel-Cell Vessels"** by Finn Vogler, GL, on 23 October at 2:00 p.m.

Related links
www.zemships.eu
www.elding.is/elding
www.fuelcellboat.nl
www.h2yacht.com
www.zebotec.de