Fuel cells starting to play part in cutting ship emissions

Germany spearheading research into an alternative source of onboard power with potential for owners and manufacturers

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Bus passengers as far apart as Beijing, Barcelona and Aberdeen may be unaware they have been participating for years in trials to test the feasibility of hydrogen fuel cells in public transport.

The technology, which offers a cleaner and more efficient source of power, is now spreading to shipping as ports, just like congested cities, apply pressure to cut vessel emissions.

More distant but also feasible is upscaling fuel cells from the current focus on auxiliaries to larger MW systems for the actual propulsion of seagoing tonnage. Vessel designs are being developed by companies such as NYK Line and Viking Ocean Cruises.

The last two years have seen a surge of interest from fuel cell manufacturers looking to gain a foothold in the maritime market, driven partly by the interest of cruiseship operators.

Norway's Moss Maritime and Japan's Kawasaki Heavy Industries are even developing bunker and longer-haul vessels, respectively, for carrying liquid hydrogen to meet expected demand as the technology takes off.

Fuel cells convert chemical energy stored in the fuel directly into electrical and thermal energy by electrochemical oxidation. NOx, SOx and particulate matter emissions can be eliminated to almost zero.

Classification society DNV GL says mass production of fuel cells is expected beyond 2022, bringing costs down to competitive levels. But only small maritime fuel cell applications with an electrical output of up to 100kW are currently in operation.

Much of the research is taking place in Germany following initiatives by cruiseship builder Meyer Werft and industrial giant ThyssenKrupp, the former owner of the Blohm+Voss shipyard in Hamburg.

They are part of the e4ships consortium involving other familiar names such as DNV GL, Flensburger Schiffbau-Gesellschaft and Lurssen shipyard, as well as equipment suppliers.

DNV GL claims in an assessment of alternative fuels that e4ships' projects, aiming for a market launch in 2022, are the most advanced in terms of future commercial applications.

Coordinating the projects is Hamburg-based hySolutions, a public-private partnership working mostly for its partners, including Hamburger Hochbahn, the public transport operator in the port city.

Heinrich Klingenberg, general manager of hySolutions, outlined for TradeWinds the key maritime projects of the partly publicly-financed e4ships and his views on future potential applications at a time when the shipping industry faces the IMO challenge of a 40% reduction in carbon emissions by 2030.

One project — the Meyer Werft-led Pa-X-ell — is using Viking Line's 2,500-passenger ropax Mariella (built 1985), which operates between Helsinki and Stockholm, to test methanol-fuelled, high-temperature proton exchange membrane (PEM) fuel cells.

Those tests include evaluating the impact on fuel cells, especially from salt water, salty air and movement of the ship, particularly the effect on energy efficiency.

Klingenberg says fuel cell efficiency achieved so far has been good, although a new test project has already started that is aimed at having more efficient technology for maritime testing in around two years' time.

The emphasis of such projects so far has been on providing vessels with combined onboard heat and power (CHP), not the main propulsion where large seagoing vessels require machine output — in the case of the 183,900-gt cruiseship AIDAnova (built 2018) — of 61.7MW.

ThyssenKrupp Marine Systems is leading the so-called SchIBZ project consortium — part of e4ships — using road-quality, low-sulphur diesel to develop a hybrid fuel cell system for seagoing ships and having a power capacity of 50 to 500kW. The project has tested a 50kW system, built in a container, on the 6,400-dwt general cargoship Forester (built 1996).

However, Meyer Werft is also heading up another project, RiverCell. It is designed for cruise vessels on inland waterways, where the brief is provision of fuel cell energy for the full power train.

RiverCell is still at the laboratory stage, but the intention is to install the system on a river cruiseship within maybe two years.

Once again, methanol is being used but Klingenberg says e4ships' ambition is a larger variety of fuels, including LNG and low-flash-point diesel.

However, he does not expect to see fuel cells being used for the full power train of large oceangoing ships for probably another five to seven years.

In the foreseeable future, e4ships is working on employing 1MW units placed in segments in several parts of a vessel.

Smaller fuel cells supplying energy for hotel requirements, navigation systems and other onboard purposes will come sooner, with various companies including cruise giant Carnival Corp interested in such applications within four or five years.

GROWING OPTIMISM IN FUEL CELL TECHNOLOGY SEES MORE PROJECTS ON

LOOK OF THE FUTURE: A computer-generated image of NYK's lightweight Super Eco Ship 2050, which will be powered by hydrogen fuel cells
Photo: NYK Line

Optimism surrounding fuel cells is growing.

Viking Ocean Cruises intends to build what it claims will be the world's first hydrogen-powered cruiseship, with fuel cells converting liquid hydrogen to electricity for propulsion and electric power onboard.

Similarly, Icelandic container line Samskip announced last month that it planned to build a pair of emission-free vessels using state-of-the-art hydrogen fuel cells for propulsion.

NYK Line's lightweight Super Eco Ship 2050 design will be powered by hydrogen fuel cells.

Royal Caribbean Cruises also wants fuel cell technology to feature on its Icon-class ships being constructed by Meyer Turku for delivery in 2022 and 2024.

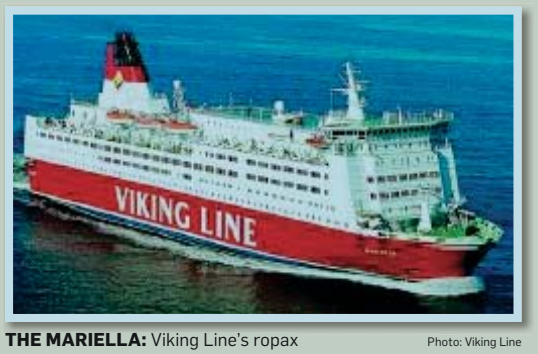
On individual fuels, hySolutions general manager Heinrich Klingenberg says LNG supply should not be an issue given the growth of LNG infrastructure in large ports, especially in Europe and the US.

Although hydrogen in liquid form occupies less space than LNG, it must be kept very cold — at -253C.

Klingenberg discounts safety as an issue in storing hydrogen on

FUEL FOR THOUGHT: (Clockwise from top) ThyssenKrupp Marine Systems' fuel cell system; Jennifer Kreissel of hySolutions; Lars Langfeldt of DNV GL-Maritime; the Pa-x-ell maritime fuel cell demonstrator onboard the Mariella

Photos: ThyssenKrupp Marine Systems, hySolutions, DNV GL and Meyer Werft



THE MARIELLA: Viking Line's ropax Photo: Viking Line

MASS PRODUCTION WILL SLASH SYSTEM COSTS BUT REGULATION POSES CHALLENGE IN FUTURE

Cruiseships are prime customers, especially given the high hotel power requirement and widespread adoption on newbuildings of LNG, which can be used both for the generator sets of the main power train and fuel cells for CHP. Fuel cells combined with electric motors are also virtually silent and vibration free.

Klingenberg says fuel cells are probably around twice as expensive as a conventional system at the moment, but the gap will close once online production brings economies of scale.

DNV GL's alternative fuels study reported current fuel cells cost between $3,000 and $4,500 per kW of installed electrical power.

But ongoing developments aim to reduce this by up to $1,000 per kW by 2022 and make them competitive with modern diesel engine installations.

"While still too expensive for the car makers, the cost of PEM fuel cells has dropped to a level that is attractive for ship applications," DNV GL said.

It says operational costs will be competitive when:

- Fuel cells are as durable as combustion engines until requiring a general overhaul;
- Cost and time of a fuel cell exchange is the same as general engine overhauls;
- Primary fuel prices are competitive with marine gasoil (MGO).

Fuel cells may also require less maintenance than conventional combustion engines and turbines.

In the Safe Return to Port regulation, subdividing say a 5kW system into 1kW units means it is easy to switch between them, increasing the level of redundancy.

Klingenberg says a problem with scaling up the technology is establishing production lines, because fuel cells are currently individually handmade.

He adds that fuel cells are around 60% energy efficient compared with conventional systems of 40% to 50%, but they still need to improve.

Lars Langfeldt, senior project engineer at DNV GL-Maritime and the class society's project manager in the e4ships consortium, says Meyer Werft is planning larger applications of around 200kW for its inland river cruiser project, and is targeting even bigger systems for cruiseships by 2021.

DNV GL has identified the three "most promising fuel cell technologies for maritime use" as solid oxide, PEMs and high-temperature PEMs.

Jennifer Kreissel of hySolutions is in overall charge of e4ships' projects.

Lars Langfeldt, senior project engineer at DNV GL-Maritime, says e4ships' target is to have maritime fuel cell applications covering auxiliary power supply market-ready in the next couple of years.

On Viking Line's ropax Mariella (built 1985) — a ship constructed in Finland at the Turku yard, now owned by Meyer Group — the methanol fuel cell system is "running well" but needs further development, especially upscaling from the current 90kW.

Langfeldt believes the technology will require another five to 10 years for large-scale applications.

As well as upscaling to multiple megawatts, he identifies the challenge of agreeing international regulations covering the likes of hydrogen, methanol and low-flash-point diesel for maritime applications.

But the cost of fuel supply will decrease as demand grows and there is a shift from trucks to bunker vessels.

Langfeldt says mass production could reduce system costs to that of diesel engines, although high-temperature fuel cells require further development and it could be another five to 10 years before such price levels are achieved.

So far, German industry has favoured high-temperature fuel cells because liquid methanol can be used and stored more easily at an ambient temperature.

Langfeldt notes that high-temperature fuel cells using natural gas are particularly interesting because the handling and storage of LNG is already regulated within the IMO's International Code of Safety for Ships Using Gases or Other Low-Flashpoint Fuels (IGF Code).

IMO sessions are said to be attracting a lot of German representatives, who are keen to see regulation introduced as early as possible.

Liquefied hydrogen, as opposed to compressed hydrogen, can be stored in larger volumes onboard vessels but, as it is not regulated, special permits involving flag states are needed — and that means more effort to secure system approval.

Bunkering also has to be, for example, from a tender vessel in the form the hydrogen is needed onboard. To convert liquefied hydrogen to compressed hydrogen is not feasible because of the need for a compressor on the ship.

At the end of last month, Norway's Wilhelmsen announced it was cooperating with Moss Maritime, DNV GL and Equinor in developing the design of a 9,000-cbm liquefied hydrogen (LH2) bunker vessel in a project sponsored by Innovation Norway.

"The vessel design comes at a time when hydrogen is finally developing into a viable solution for the larger market," Wilhelmsen said.

Langfeldt says many manufacturers previously concentrating on automotive fuel cells are now also looking at maritime applications.

For example, DNV GL has granted approval in principal to Norwegian joint-venture manufacturer Hyon for its fuel cell-based power-generating system to be installed on vessels.

It can be installed above or below the main deck using up to 20-foot containers to generate power.

OWNERS' DRAWING BOARDS

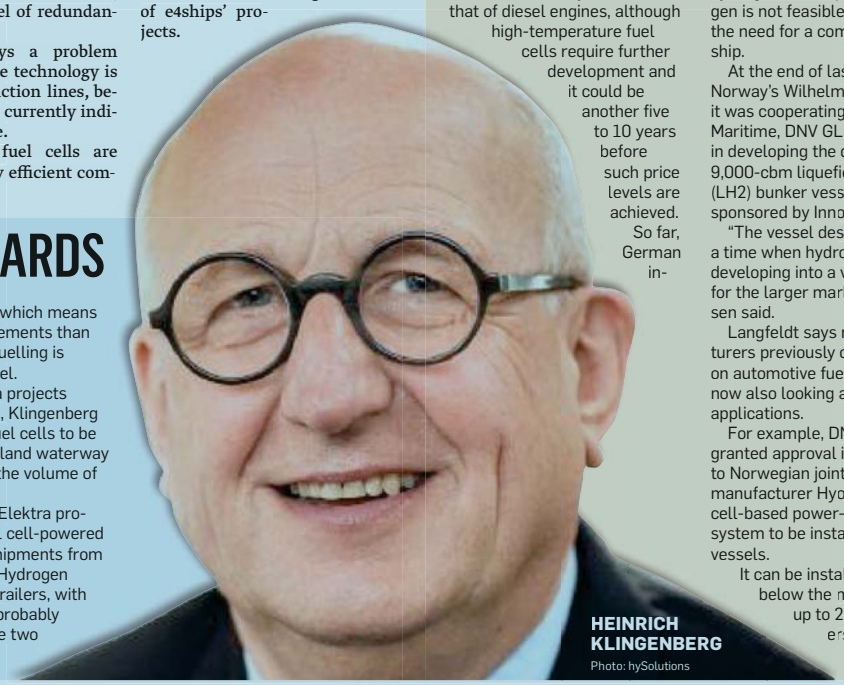
passengerships, given that 10 years of use in public transport throughout Europe has not resulted in any serious incidents.

But all fuel cells that e4ships is using for vessels are high temperature 600C to 700C — either PEM or solid oxide — which should hasten their adoption because suitable fuels such as methanol and LNG are easier to use than hydrogen and supply infrastructure already exists.

Germany has been designing submarines with fuel cells for many years but they are low-temperature PEM units normally requiring hydrogen, which means higher safety requirements than methanol where refuelling is similar to using diesel.

Although deepsea projects are being developed, Klingenberg expects hydrogen fuel cells to be used primarily for inland waterway vessels because of the volume of energy required.

He cites e4ships' Elektra project, a hydrogen fuel cell-powered tug to haul inland shipments from Berlin to Hamburg. Hydrogen will be supplied by trailers, with a refuelling station probably halfway between the two cities.



HEINRICH KLINGENBERG Photo: hySolutions