



Fuel cells

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- In container trade alone the equivalent of 125 million twenty-foot containers being shipped worldwide.
- It is these quantities that make shipping such a significant contributor to greenhouse gas emissions, accounting for almost 5% of total man-made carbon dioxide emissions , according to the latest comprehensive study by the International Maritime Organisation (IMO) and
- CO₂ emissions from ships are projected to be more than double by 2050.



- ▶ The IMO is working towards global agreements on CO₂
- ▶ So far it has achieved an energy efficiency standard for new ships from 2015
- ▶ But progress is slow, leading to threats from the European Union to impose its own limits within its waters.



- ▶ But air pollution is as much a concern as GHG emissions.
- ▶ While a country may impose strict limits on the quantities of pollutants that can be emitted by road transport, necessitating the use of catalytic converters on vehicle exhausts, its harbours will host ships for which limits are much looser



- ▶ Even ships burning cleaner diesel fractions may emit more than necessary, due to a lack of exhaust after treatment.
- ▶ Ships number is in the tens of thousands, so how severe can the effect on air quality really be?



- ▶ It has been found that globally, commercial ships emit almost half as much particulate matter pollutants into the air as the total amount released by the world's cars



- ▶ However, regulatory limits on these pollutants are becoming progressively tighter, with certain Emissions Control Areas deemed especially sensitive and subject to a higher level of protection.
- ▶ Necessitating the concept of ‘zero emission’



- ▶ So is it possible that fuel cells have a role to play in international shipping?

History and development



- ▶ Evaluation of Solid oxide fuel cell technology running on methanol for ship's auxiliary power was carried out
- ▶ Installation of a 20 kW fuel cell system – on the car carrier M V Undine



The 2009/2010 trial showed that the use of fuel cell technology and an alternative fuel poses no more of a risk to a commercial vessel than conventional equipment and fuel, laying the foundation for further deployment.



- ▶ The gas–electric propulsion system of the Viking Lady facilitated the installation of fuel cell, in September 2009,
- ▶ 330 kW molten carbonate fuel cell on the ship
- ▶ During the trial, the fuel cell logged 18,500 successful operating hours, providing supplementary power to the ship at an electrical efficiency of over 52% at full load.
- ▶ Installing a battery pack for energy storage.



- ▶ 32 kW PEM fuel cell from Hydrogenics (hydrogen is stored in an on-board tank) was installed in a passenger ship.
- ▶ 8.3 MW fuel cells draw fuel from 140 m³ hydrogen tanks, sufficient for a passage of 48 hours at 17 knots. (being used by Scandlines for their ferries)



TYPES OF FUEL CELLS

- ▶ Alkaline (AFC)
- ▶ Proton Exchange Membrane (PEMFC)
- ▶ Phosphoric Acid (PAFC)
- ▶ Direct Methanol Fuel Cell (DMFC) (CH_3OH)
- ▶ Molten Carbonate (MCFC)
- ▶ Solid Oxide (SOFC)

Proton Exchange Membrane (PEMFC)



- ▶ uses a water-based, acidic polymer membrane as its electrolyte, with platinum-based electrodes.

Proton Exchange Membrane (PEMFC)



PEM Fuel Cell_ How it works - YouTube (360p).mp4

MOLTEN CARBONATE FUEL CELL



- ▶ use an electrolyte composed of a molten carbonate salt mixture suspended in a porous, chemically inert ceramic matrix.
- ▶ Molten carbonate fuel cells (MCFCs) are currently being developed for natural gas, biogas (produced as a result of anaerobic digestion or bio mass gassification), and coal-based power plants

MOLTEN CARBONATE FUEL CELL



Molten carbonate fuel cell Top # 9 Facts - YouTube (360p).mp4

Phosphoric Acid (PAFC)



- ▶ Phosphoric acid fuel cells (PAFCs) consist of an anode and a cathode made of a finely dispersed platinum catalyst on carbon and a silicon carbide structure that holds the phosphoric acid electrolyte.

Direct Methanol Fuel Cell (DMFC)



- ▶ The platinum–ruthenium catalyst on the DMFC anode is able to draw the hydrogen from liquid methanol (CH_3OH), eliminating the need for a fuel reformer.
- ▶ Therefore pure methanol can be used as fuel, hence the name.



Solid oxide fuel cell

- ▶ For a solid oxide fuel cell, the electrolyte is a solid ceramic material.
- ▶ The anode and cathode are made from special inks that coat the electrolyte.
- ▶ Unlike other types of fuel cells, no precious metals, corrosive acids, or molten materials are required.

SOLID OXIDE FUEL CELL



Solid Oxide Fuel Cell - YouTube (360p).mp4

Why are they so promising?



- ▶ **Nearly Zero Emissions**
- ▶ **High Electrical Efficiencies**
- ▶ **Modular Distributed Power Homes outside the power grid ('PIMBY')**
- ▶ **Mobile Power**
- ▶ **Freedom from fossil fuels**
- ▶ **Silent operation**

Feasibility and Design



- The study indicates,
- “...fuel cell powered equipments has tremendous potential in reducing fuel consumption and NOx emissions. The associated economic and environmental benefits present a great incentive for naval and maritime industry to pursue fuel cell technology for the next generation cargo ships.”



- ▶ Increased availability of alternative fuels, such as LNG and hydrogen, may also accelerate introduction.
- ▶ It is concluded that fuel cells for shipping require further R&D before this technology can complement existing powering technologies.



Thank you