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Ship Powering Options for the Future

An Outline Synopsis of the Study

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Maritime Studies at City University London

Propeller Vibration

Marine Supply Chain Dynamics

Institute of Cavitation Research

MSc Maritime Operations and Management

Container Port Logistics

Ship Powering

Ship Efficiency

Offshore supply boat efficiency

RAEng

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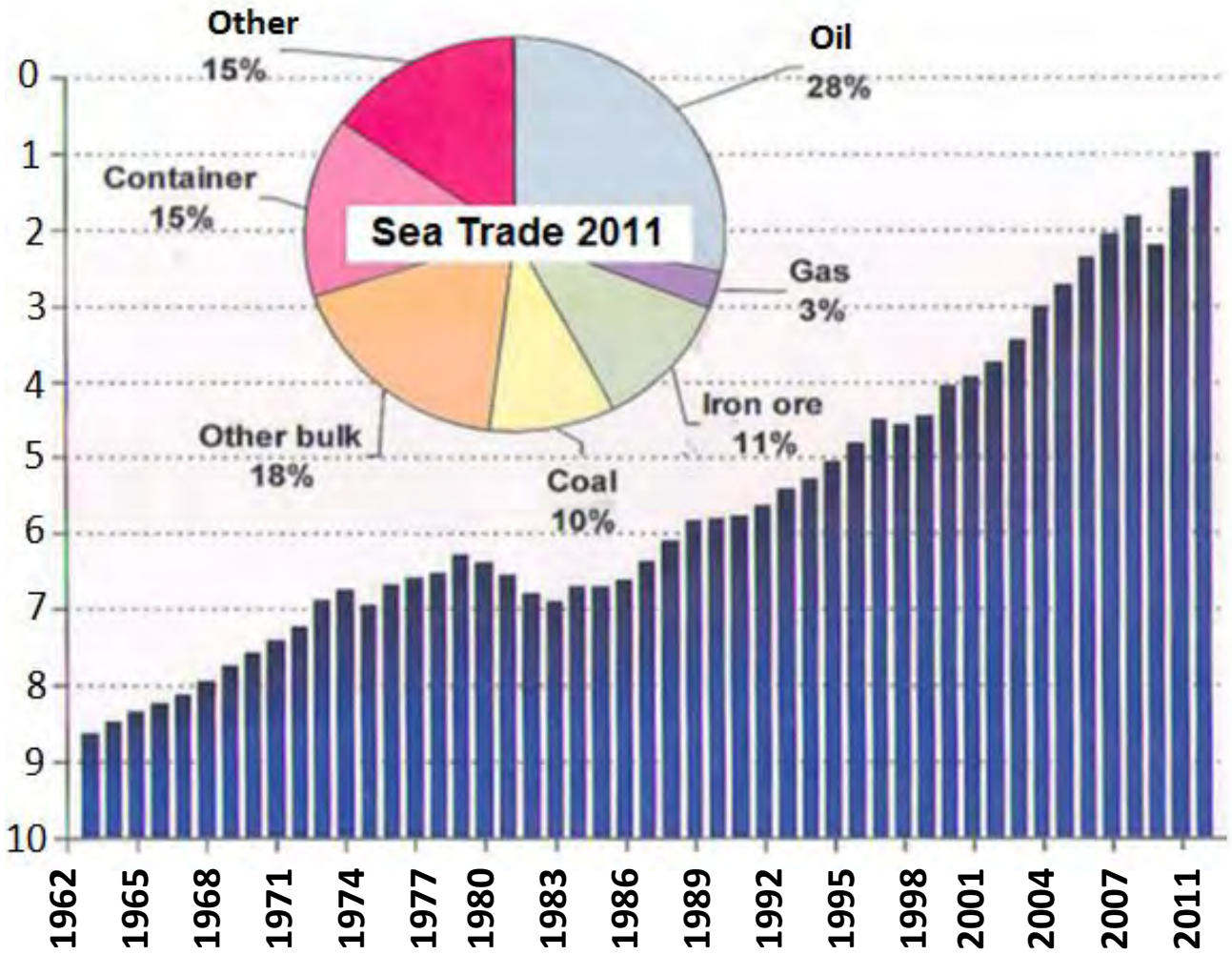
The Trend in Cargo Growth 1962 – 2011 [Stopford]



95% of world trade is moved by sea

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Main Reasons for Research into Alternative Ship Propulsion Methods

- **Rising fuel prices**
- **Environmental regulations (EEDI)**
- **The potential introduction of Carbon Taxes**

Are the current methods of ship propulsion sustainable?

If not, what are the options?

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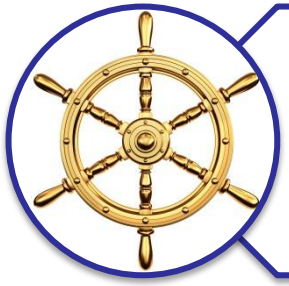
Overview of the Options Studied

Design Options

Propulsion Options



Ship Operation

- Diesel engines
- Bio-fuels
- Natural gas
- Gas turbines
- Nuclear
- Batteries
- Fuel cells
- Renewables
- Hydrogen
- Anhydrous ammonia
- Compressed air and nitrogen
- Hybrid propulsion
- Superconducting electric motors
- Propulsors
- Hull design

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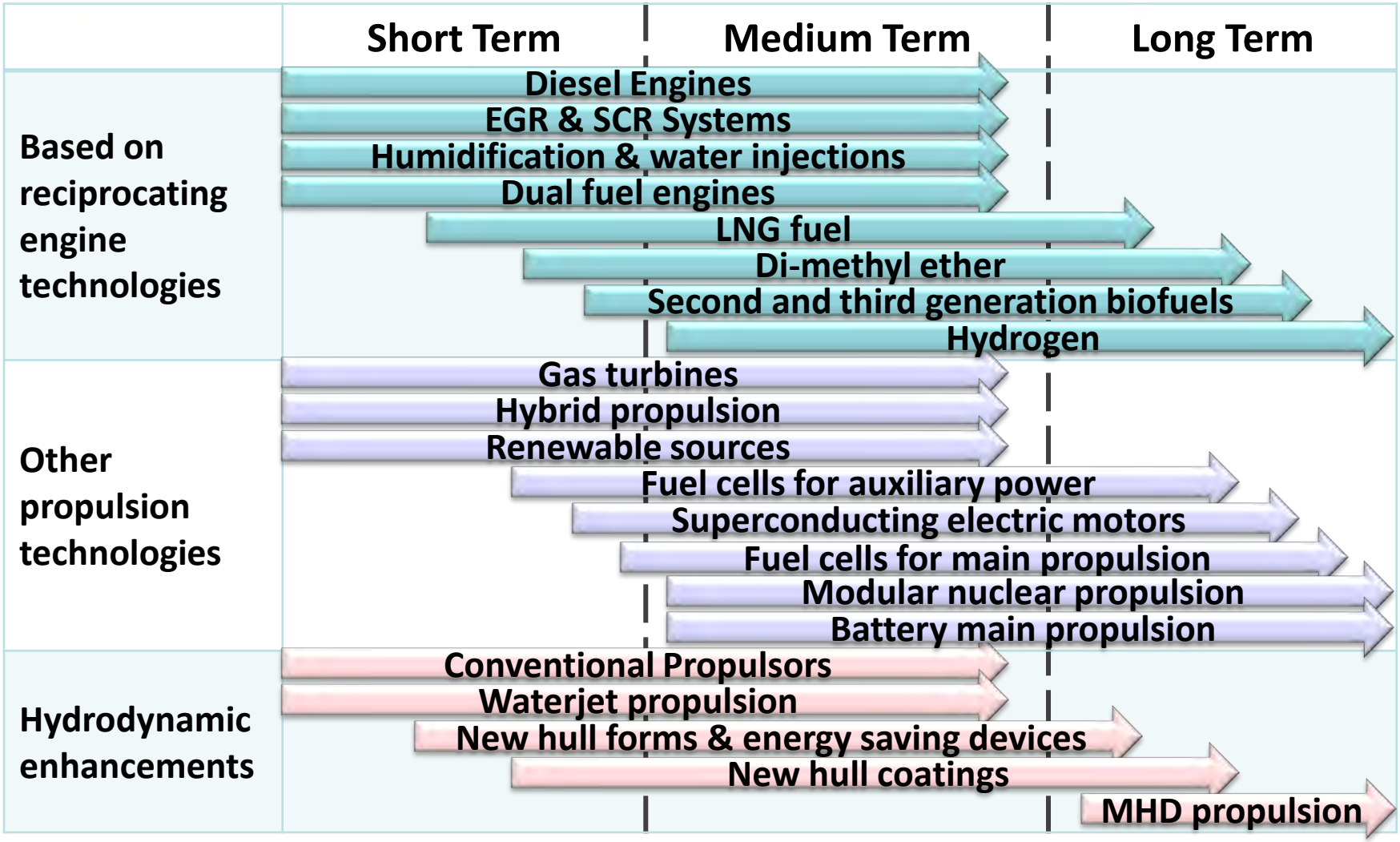
Potential Time Frame for Technologies



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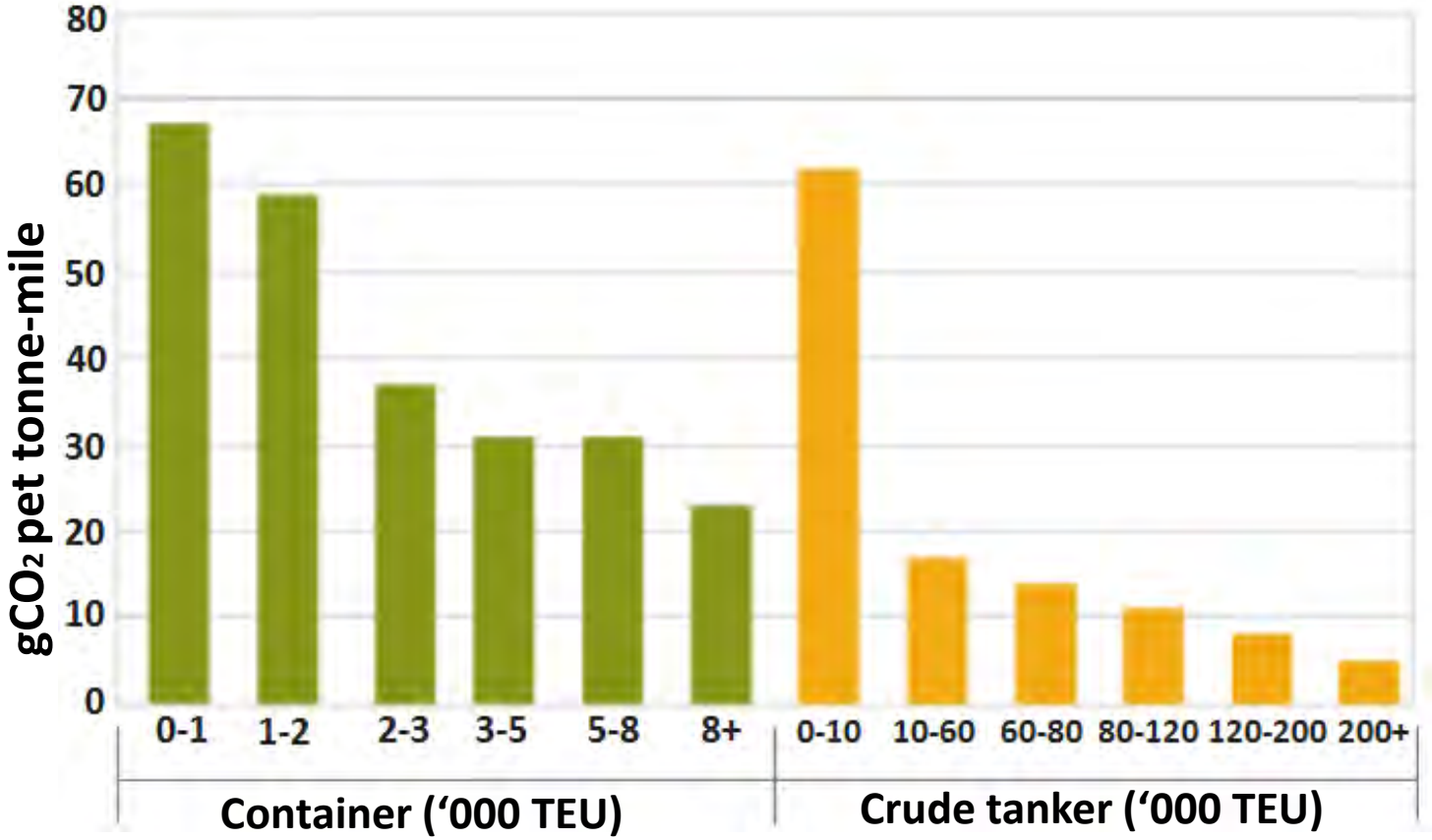
Carbon Efficiency Related to Ship Size



Therefore, for a given trade the largest ship, consistent with the trade route restrictions, is likely to be the most carbon efficient.

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Ship Powering Design & Operational Optimisation

Ship systems approach is critical for:

- Overall efficiency optimisation
- Minimisation of CO_2 and other emissions

Operational optimisation:

- Crew training
- Weather routing
- Voyage optimisation has demonstrated **7%** for ferry
- Maintenance of machinery

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Lower Ship Speeds

- Low speed leads to significant reduction in fuel/emissions
- De-rating engines – has to be done in conjunction with manufacturers guidelines
- The fitting of smaller engines – significant operational risks in poor weather for an equivalent size of ship

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Fuels

Conventional fuels (HFO, MDO)

- Infrastructure exists

Liquefied natural gas (LNG)

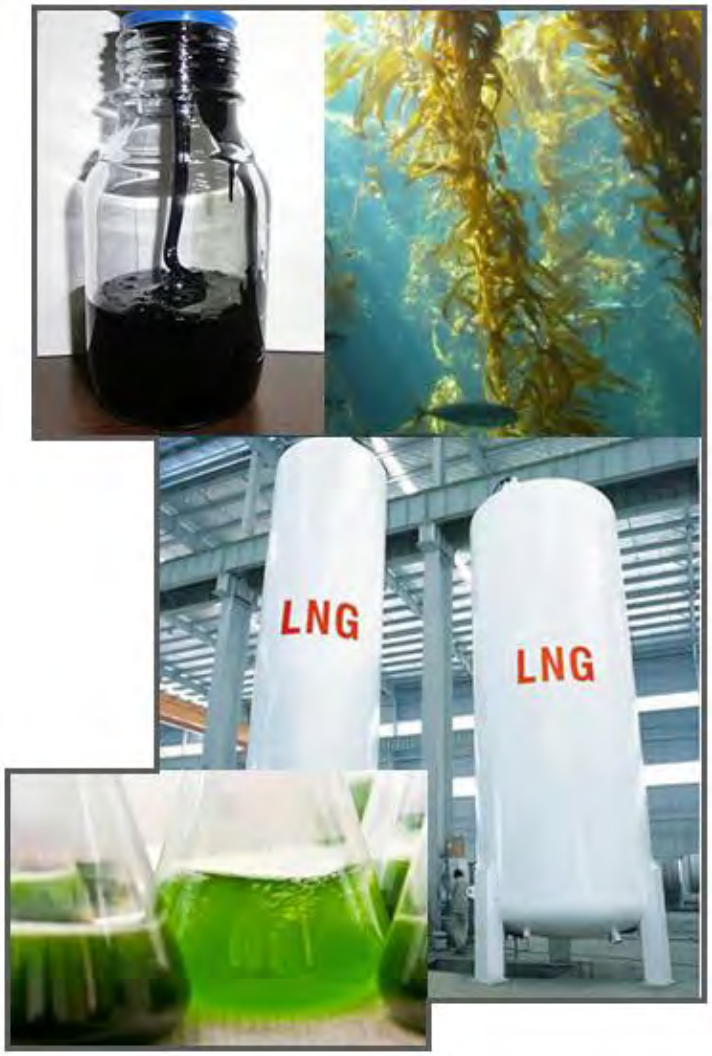
- Technology exists
- Full infrastructure required
- Ships being ordered

1st and 2nd Generation biofuels

- Filter problems with 1st generation, (FAMEs)
- Currently arising from contamination of fuel supply
- Problem can be managed.
- Infrastructure required for 2nd generation supply

Di-methyl ether

- Issues with lubricity
- Requires additional research



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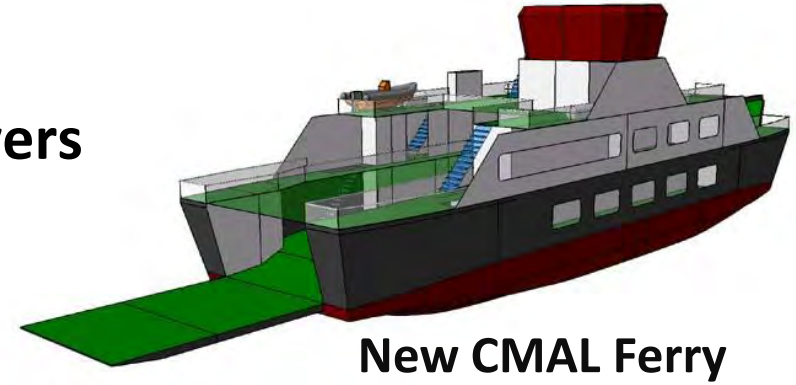
Hybrid Propulsion

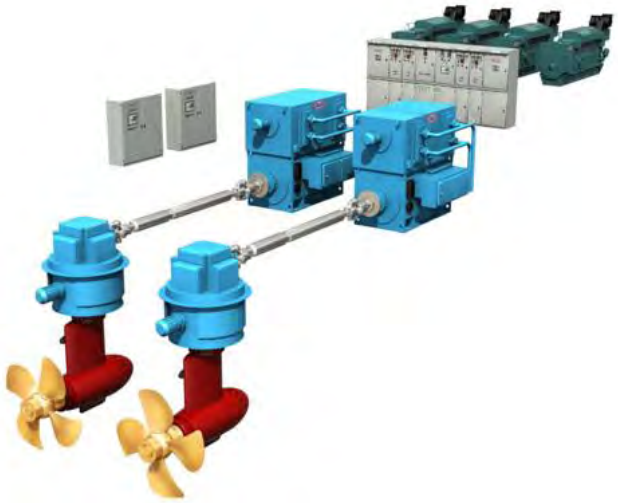
Typical combinations of prime movers and energy storage media:

- Diesel – battery – shore charging
- Diesel-electric propulsion
- CODAG, COGAG, CODLAG warships



New CMAL Ferry

The precise combination for a given ship project is dependent on the operational profile, location, port facilities, environmental regulations, etc



Nuclear Propulsion

Advantages

- No atmospheric emissions (CO_2, NO_X, SO_X, volatile organic and particulate matter)
- Significant experience in the design and safe operation
- Minimum refuelling, maintaince, repair and decommissioning issues
- There is a good case for considering modular reactors with merchant ships
- Flexibility in ship speeds, hull form and ship numbers deployed on a route
- Relatively stable *term fuel prices*

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Nuclear Propulsion

Disadvantages

- Significant changes and constraints for planning, ship design and operation
- Relatively small number of nuclear propulsion experts at all levels
- Insurance issues are significant for merchant ships
- New developments in legislation, infrastructure, crew training

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Renewable Energy

Advantages

- Renewable power is free from atmospheric emissions
- Partial propulsion benefits can be achieved through wind based methods
- Solar power has been demonstrated to augment auxiliary power

Disadvantages

- Wind power systems rely on the wind strength to be effective.
- Additional installation and maintaining of control system technologies on board
- Solar power availability is global position dependent.
- Photovoltaic processes have low effectiveness and require a significant deck area to install an array of cells.

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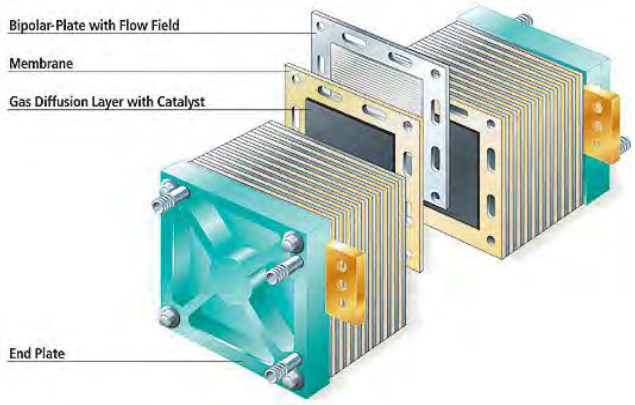
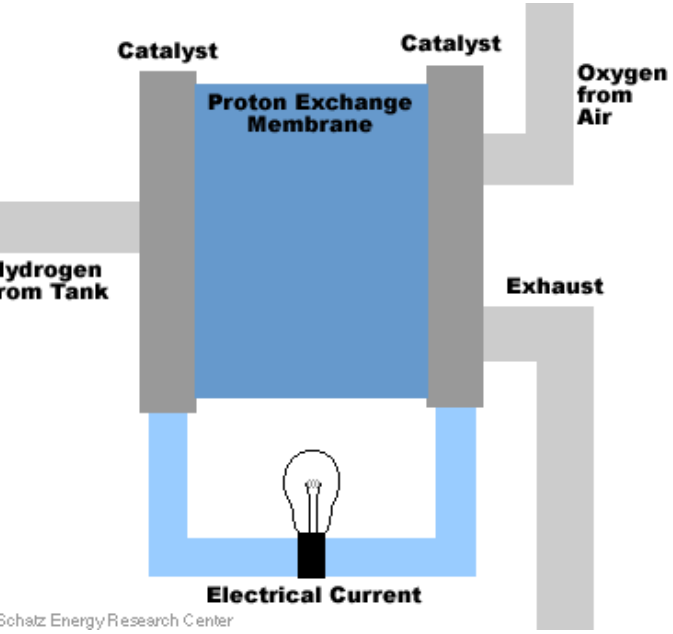
Fuel Cell Technology

- **The most promise**: the high temperature solid oxide and molten carbonate fuel cells
- **For lower powers**: the low temperature proton exchange membrane fuel cells
- Hydrogen - no carbon dioxide emissions
- Methanol can also be used
- It is suitable to ships with electric transmissions because fuel cells deliver DC power
- No moving parts





Fuel cell technology

Disadvantages

- Require a worldwide marine infrastructure for the fuel
- Not so suited to ships with mechanical transmission systems
- Lower specific powers and power densities than diesel engines

Principal Options

For existing ships reciprocating engines:

- exhaust gas attenuation technologies
- fuels having less CO_2 emission potential, for example LNG

In the short term for new buildings (additional options):

- hybrid propulsion systems (depend on the ship size and its intended duty cycle)

New ships contemplated for the medium to long term:

- alternative fuel options
- fuel cells
- nuclear propulsion
- hybrid propulsion

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