Germanischer Lloyd

The “zero-emission perspective”

from a vision to a real perspective / *the energy turnaround at sea*

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Content

- the starting point:
  - „vision of a zero-emission container feeder vessel“
  - the concept design, the economy
- were does the sustainable energy come from:
  - offshore wind to hydrogen
  - onshore production of H2 / „windgas“
- the order: Scandlines ordered a feasiblity study:
  - Zero-emission ferry connection, Fehmarnbelt
  - concept design, possibilities & constraints
- what kind of H2: liqufied / compressed gas (LH2 / CH2)
- will a LH2-fuelled ship be competitive?

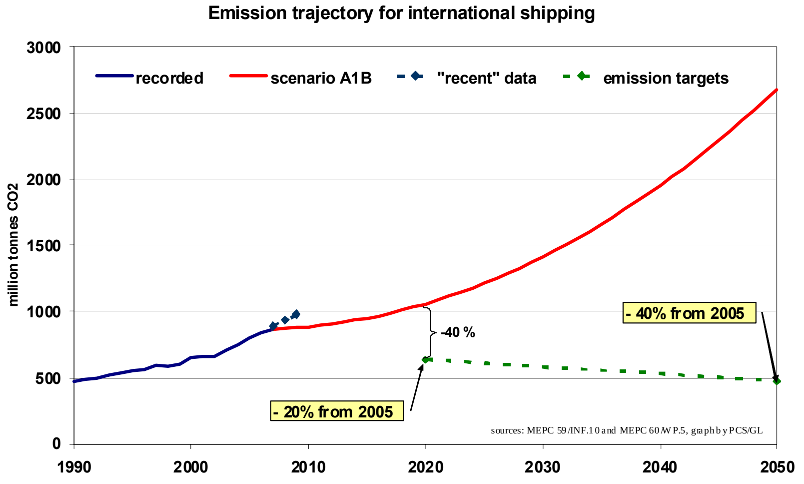
The challenges and our motivation

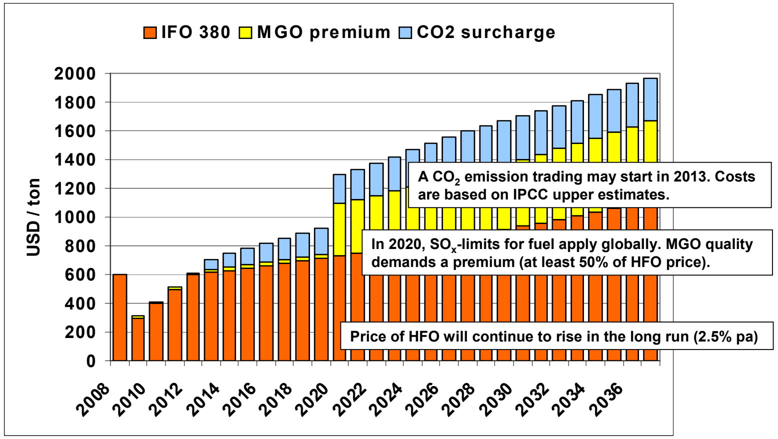
With expected fleet growth to meet world transport demand for the next decades, CO_2-emissions from shipping will increase.

Even if known and available measures will be implemented, shipping will likely not meet the discussed emission targets.

At the same time, fuel prices will continue to increase with future oil reserves being more remote and requiring more technology.

Therefore, it is time to consider novel solutions to enable future zero-emission shipping. GL Research and Rule Development looks at novel technologies beyond current applications.





Source: GL research. The analysis excludes inflation effects.

One solution – Hydrogen as fuel

The new zero-emission container feeder vessel design concept has fuel cells and tanks to hold liquid Hydrogen for a typical roundtrip.

The vessel stops every ten days at an offshore station for bunkering.

An offshore station produces liquid Hydrogen by using surplus wind energy. The Hydrogen is stored for short periods.

The Hydrogen-fuelled container feeder vessel

The new container feeder vessel targets traditional trades.

- full open-top 1000 TEU intake with 150 reefer slots, service speed of 15 knots

The new container feeder vessel runs on liquid Hydrogen.

- 5 MW fuel cell systems, with 3 MWh battery systems to provide peak power
- multiple type C tanks with 920 m^3 to hold liquid Hydrogen for a ten-day roundtrip

Investment for LH2-fuelled container feeder vessel

The LH2-fuelled container vessel has significant higher investment costs:

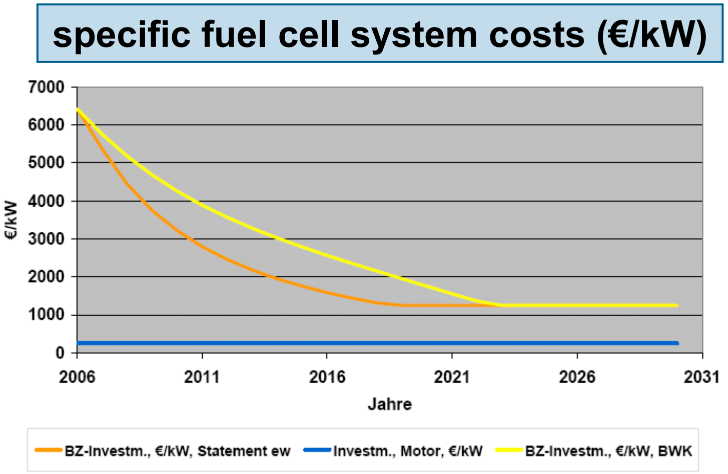
- LH2-fuelled: 35 m$
- HFO-fuelled: 22 m$

The additional invest is mainly for:

- type-C tanks (37%)
- fuel cell systems (57%)
- battery system (6%).

Data used to estimate costs:

- 2009 LNG-fuelled feeder study
- GL market study on fuel cell systems



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Liquid Hydrogen offshore production potential

In 2020, about 3GW generation capacity is assumed to be installed in offshore wind energy parks in the German Exclusive Economic Zone.

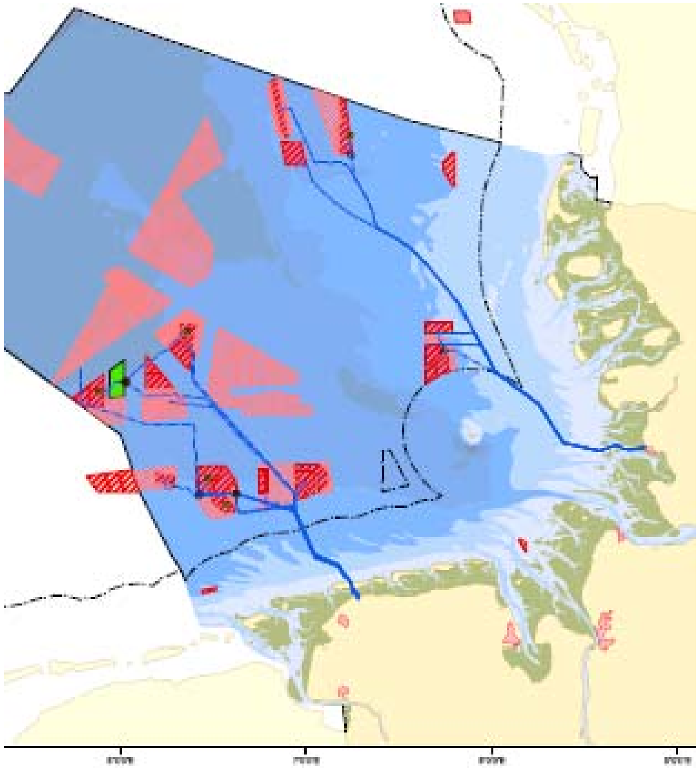
Up to 30% of the generated power may not be put into the grid and could be available for Hydrogen production (up to 3600 GWh/a).

A 500 MW wind farm may produce up to 6.000 t liquid Hydrogen (LH2) using its surplus power. This could serve 3 feeder vessels.

An intermediate storage of LH2 for up to 10 days requires insulated tanks of up to 3000 m³.

Costs for LH2 are based on invest for production, liquefaction and storage installations.

Offshore wind farms in German EEZ of North Sea



source: BSH,
http://www.bsh.de/en/Marine_uses/Industry/CONTIS_maps/index.jsp

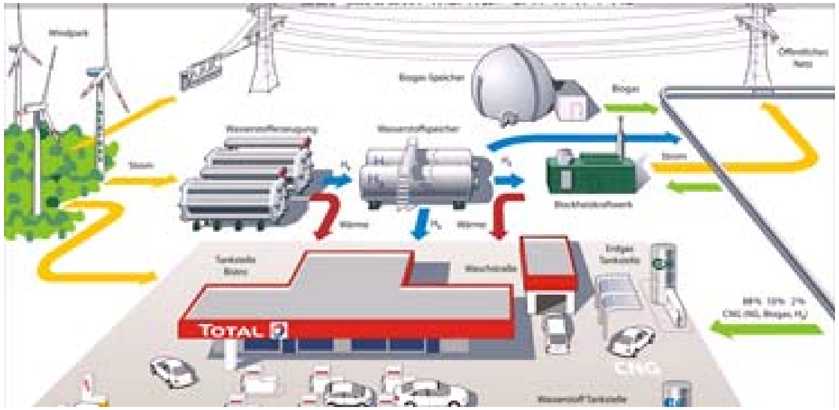
Onshore systems use surplus wind energy today

Hydrogen-hybrid power plant in Prenzlau

- wind energy produces Hydrogen
- 500 kW electrolysis system
- intermediate storage in tanks
- use of Hydrogen in power plant or by cars (at special fuel stations)
- cooperation of Enertrag, Total, Vattenfall

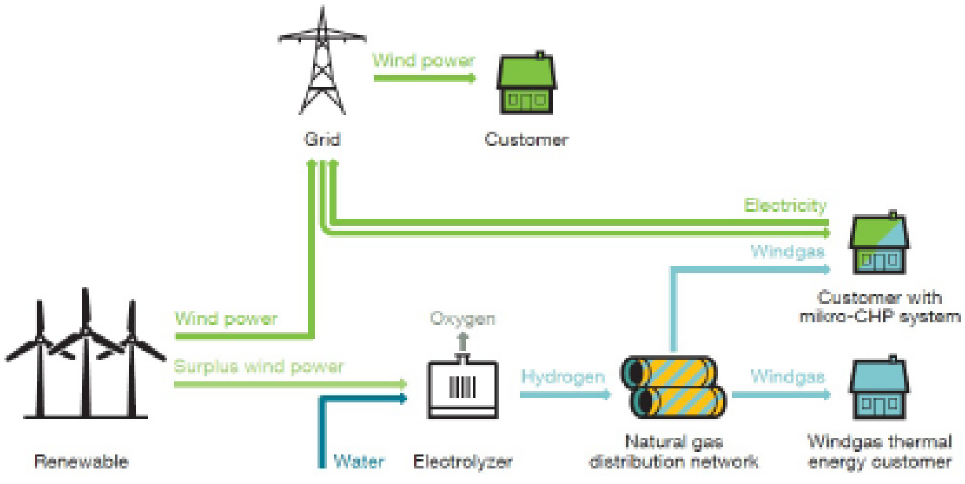
Power to gas plant in Falkenhagen

- wind energy produces Hydrogen
- 2 MW electrolysis system
- Hydrogen is being put into natural gas pipeline system
- Operated by EON
- partner is *greenpeace energy*

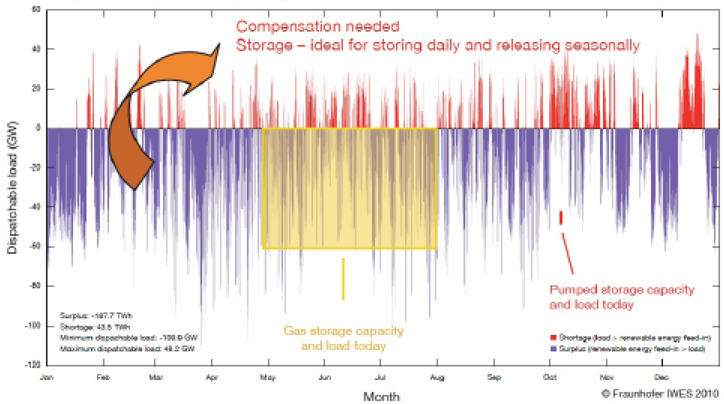


greenpeace energy „windgas“

.. using the natural gas grid for the storage of hydrogen produced from surplus (offshore) wind power....
...up to 5% of hydrogen in the pipe grid is possible!

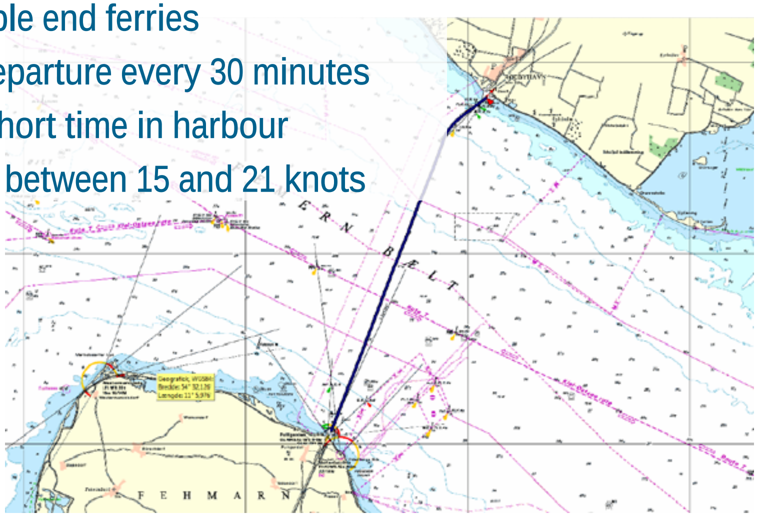


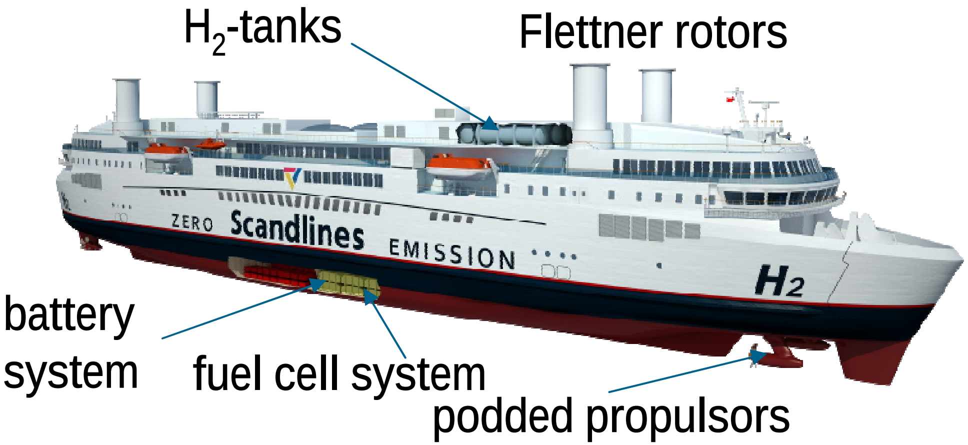
Windgas: The Mechanics



Design concept for a zero-emission ferry

- 4 double end ferries
- one departure every 30 minutes
- very short time in harbour
- speed between 15 and 21 knots

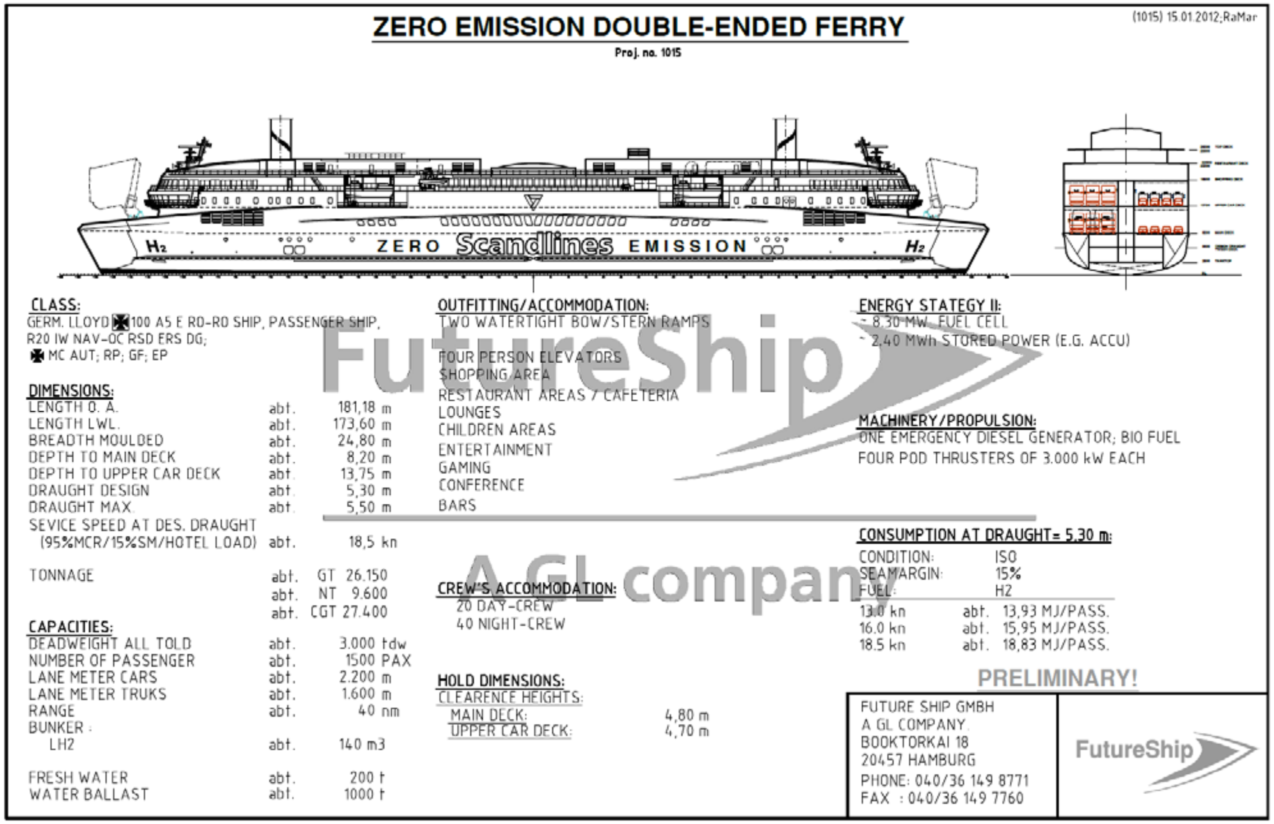




source: Scandlines 2012

Zero Emission Scandlines ferry

... from operational profils over efficiencies to energy demand



1500 passengers

18,5 knots

2.200 lane meters

140m³ H2-tanks

8300 kW fuel cells

2400 kWh batteries

4 x 3MW pod - propeller

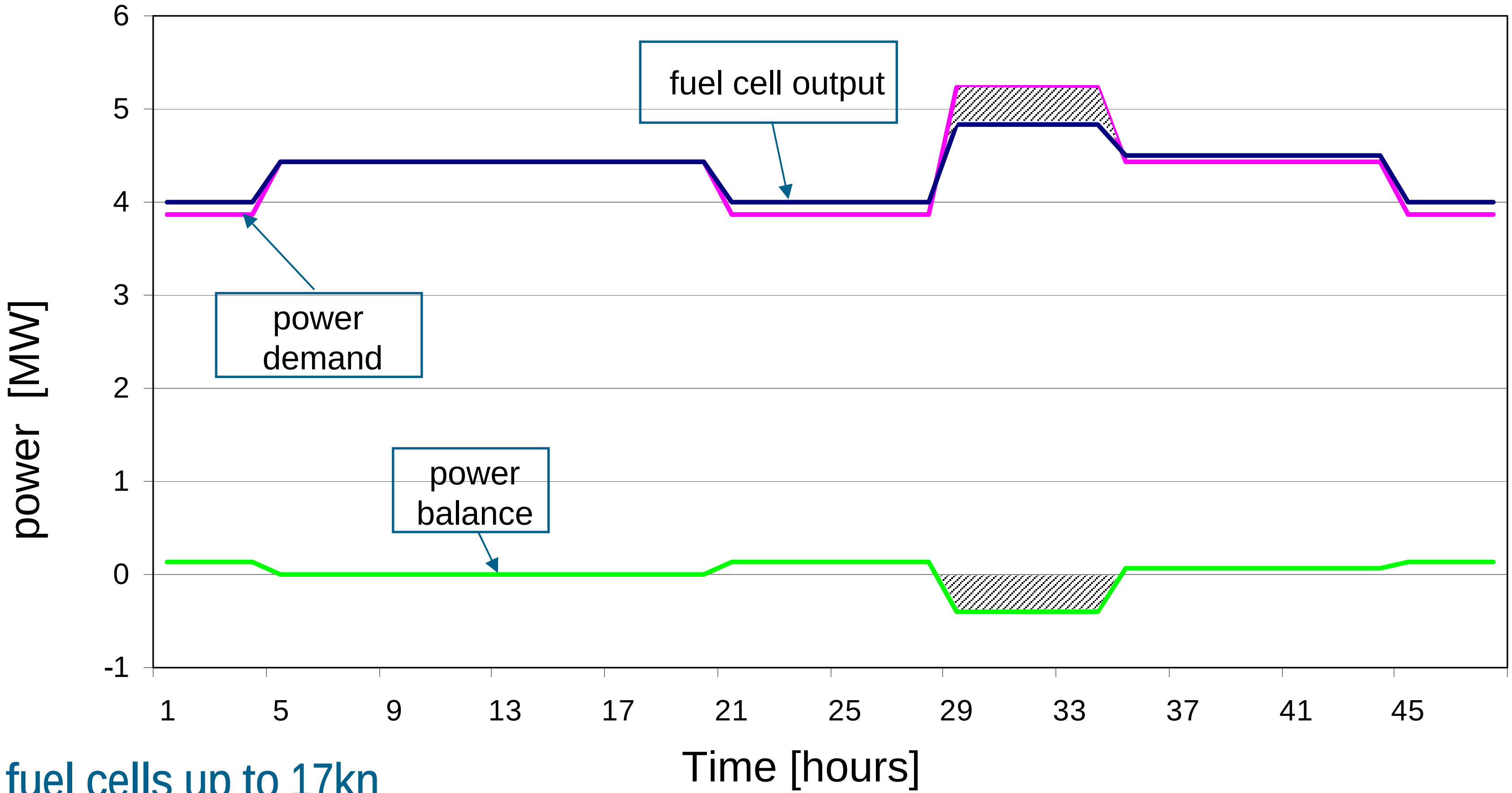
energy demand per trip

16,0 kn → 16 GJ

18,5 kn → 19 GJ

Zero Emission idea and concept

Energy converter / reduced consumption

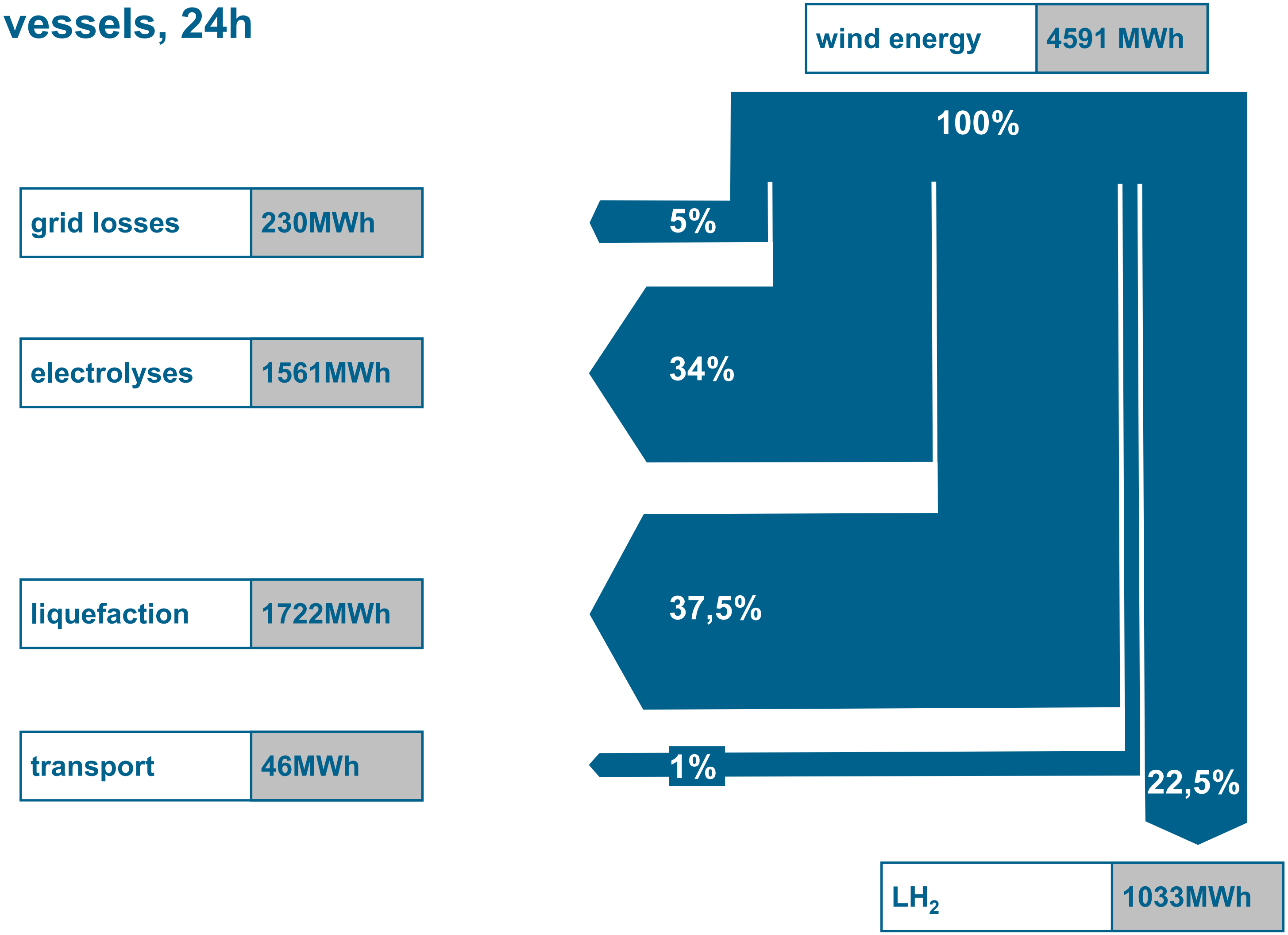


fuel cells up to 17kn

battery support from 17 to 18,5 kn

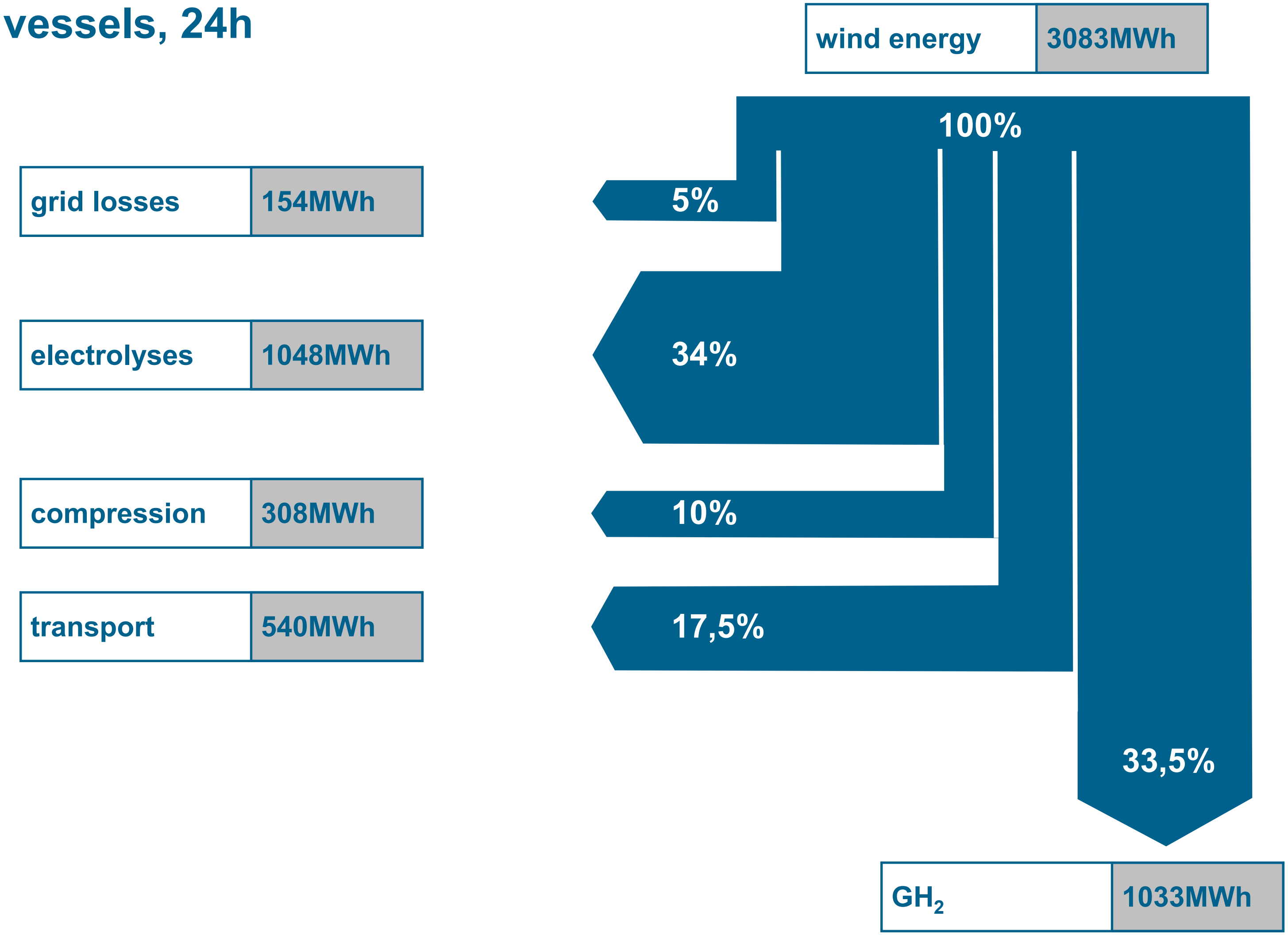
Liquid Hydrogen: from Windpower to Bunker Station

basis: 4 vessels, 24h



Gaseous Hydrogen: from Windpower to Bunker Station

basis: 4 vessels, 24h



Global Remarks

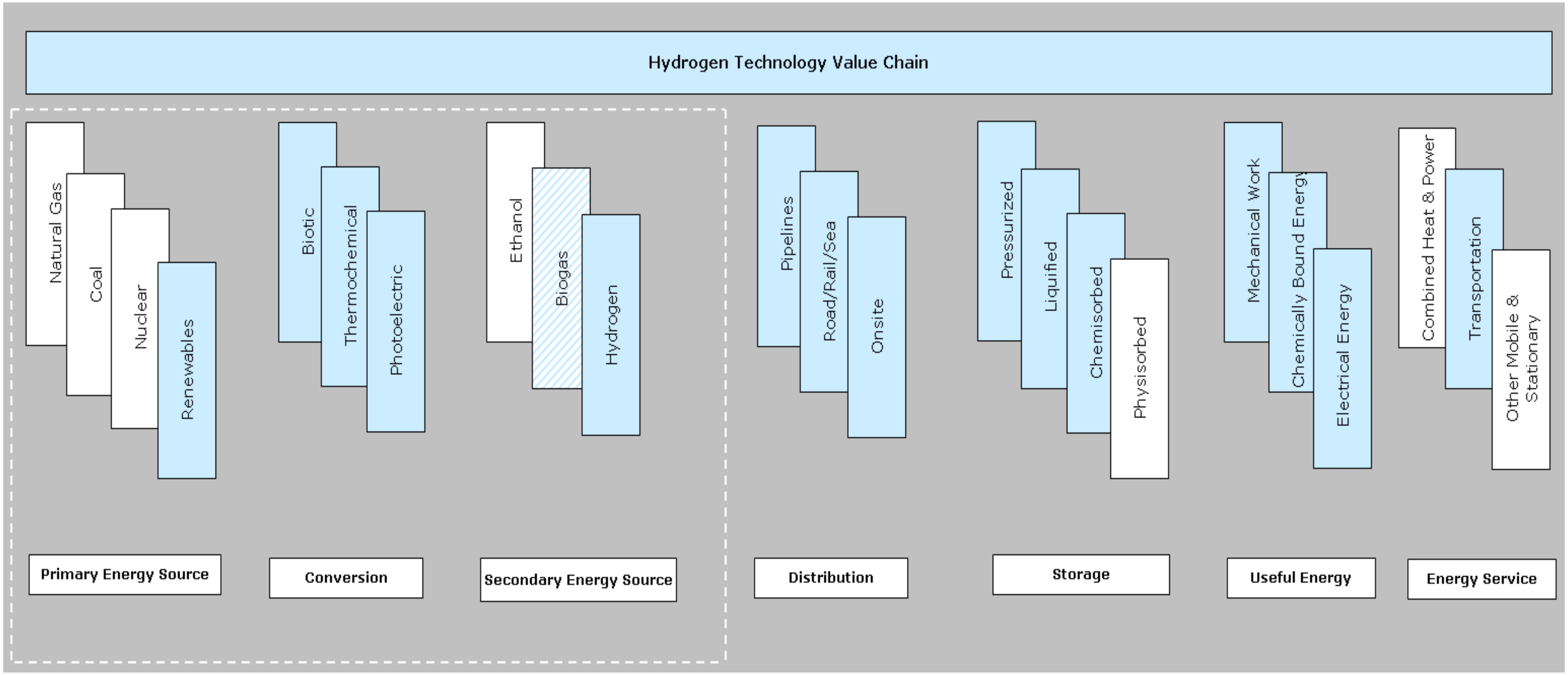
Hydrogen system energy efficiencies highly disputed in a number of sources.

The likely cause is a combination of aging results, varied assumptions, and the application of different terminologies (e.g. electrolysis versus electrolyser system).

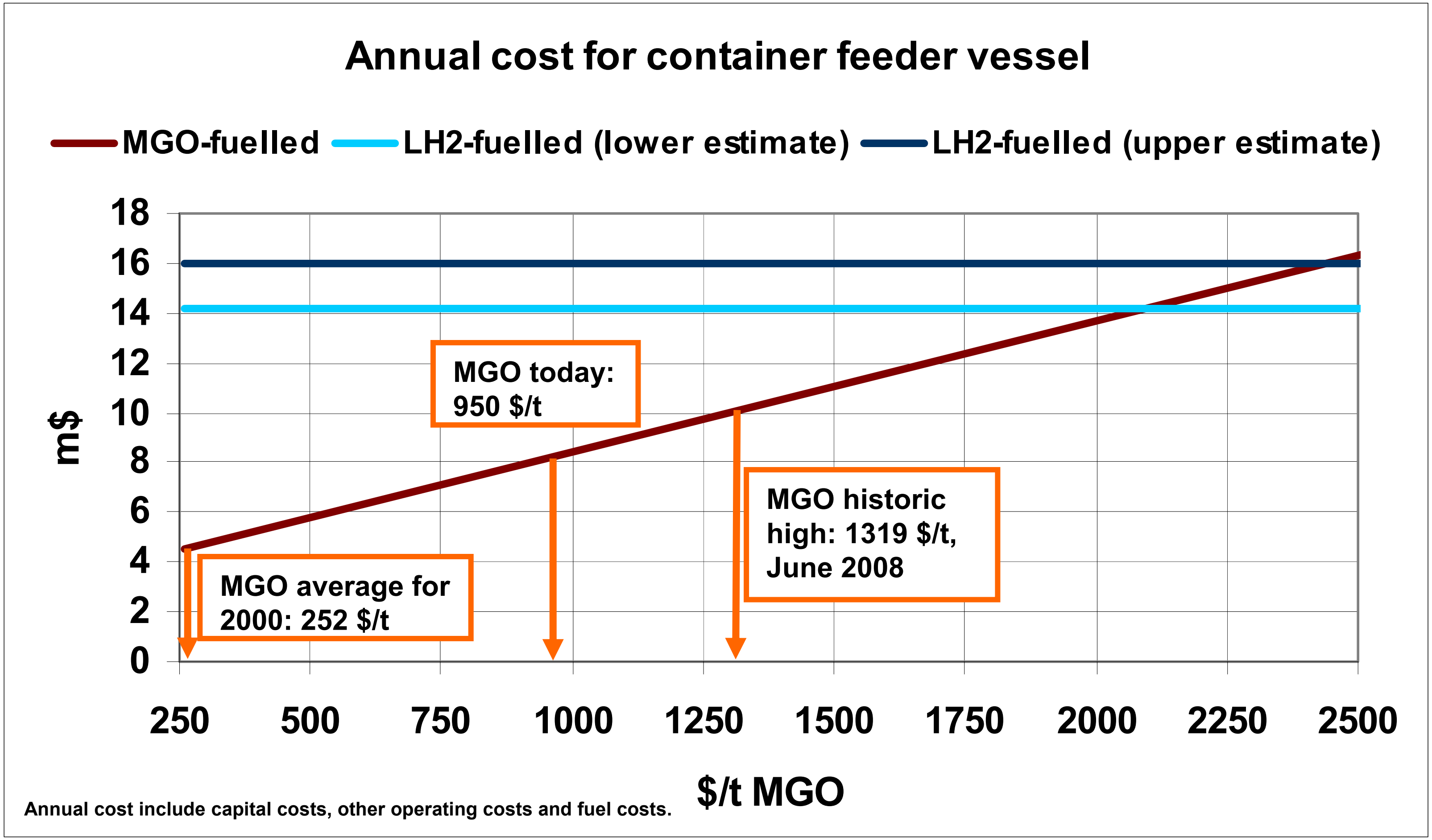
The following key parameter require thorough analysis BEFOREHAND as they have a significant impact on the overall energy requirement:

1) feed water supply (treatment and logistics)
2) further use of excess heat from electrolysis
3) type of electrolysis system (incl. input pressure, arrangement (modular, central))
4) liquefaction cycle arrangement
5) pipeline dimension, pressure level and distance

Energy Resources Background (I)



Will a LH2-fuelled ship be competitive?



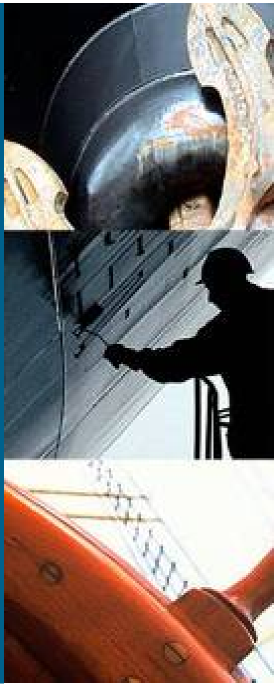
conclusion & outlook

A vision for a zero-emission container feeder vessel was created. The vessel will run on liquid Hydrogen produced by offshore wind farms' surplus energy.

The LH2-fuelled container feeder vessel may become economically attractive when MGO prices increase beyond 2.000 $/t.

A design concept for a zero-emission ferry was developed with Scandlines.

GL expects first dedicated zero-emission ships on short-sea routes.



Thank you for your kind attention.

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