Future Fuels in Shipping – Opportunities and Costs

Ship Efficiency Conference, Hamburg, 23 a 24.09.2019

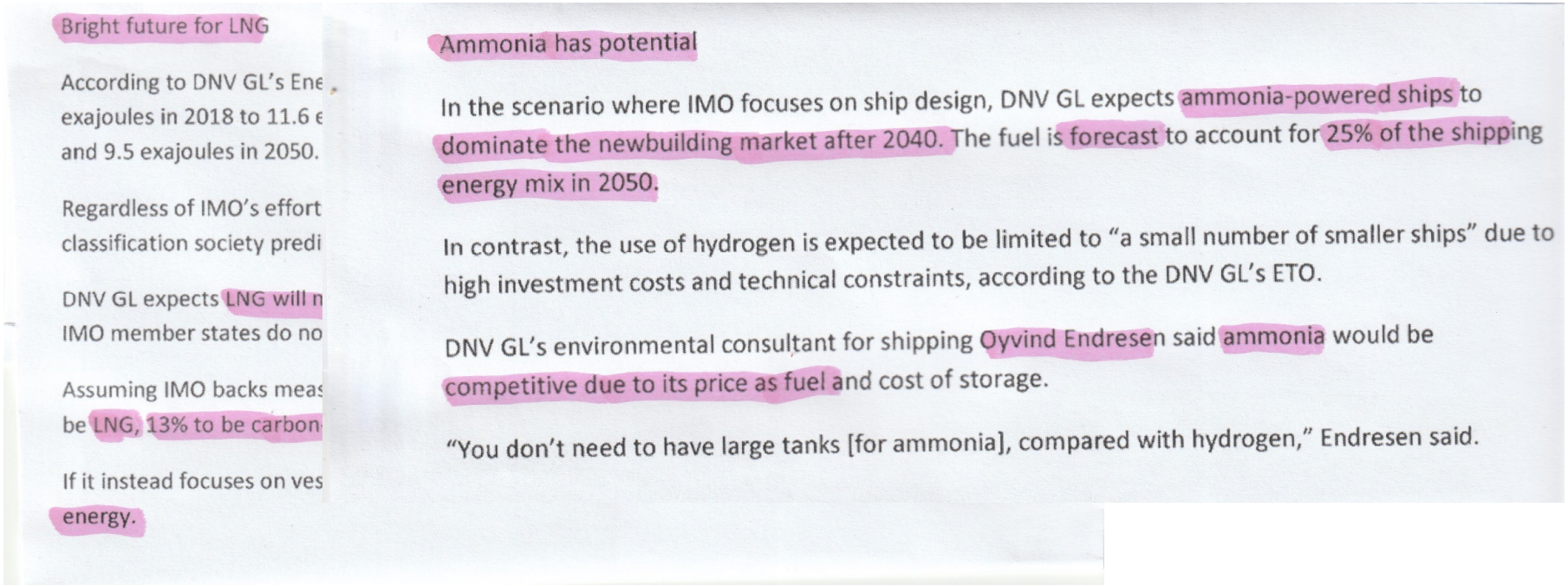
Schiffbautechnische Gesellschaft e.V.

GMW Consultancy – Marine-, Process-, Energy Technology -

DNV GL forecast 2050 – London Shipping Week Sept 2019 -

DNV GL: LNG will be top marine fuel by 2050 as ammonia beats hydrogen

TradeWinds 11.09.2019



Bright future for LNG

According to DNV GL's Ene
exajoules in 2018 to 11.6 e
and 9.5 exajoules in 2050.

Regardless of IMO's effort
classification society predi

DNV GL expects LNG will n
IMO member states do no

Assuming IMO backs meas
be LNG, 13% to be carbon

If it instead focuses on ves
energy.

Ammonia has potential

In the scenario where IMO focuses on ship design, DNV GL expects ammonia-powered ships to dominate the newbuilding market after 2040. The fuel is forecast to account for 25% of the shipping energy mix in 2050.

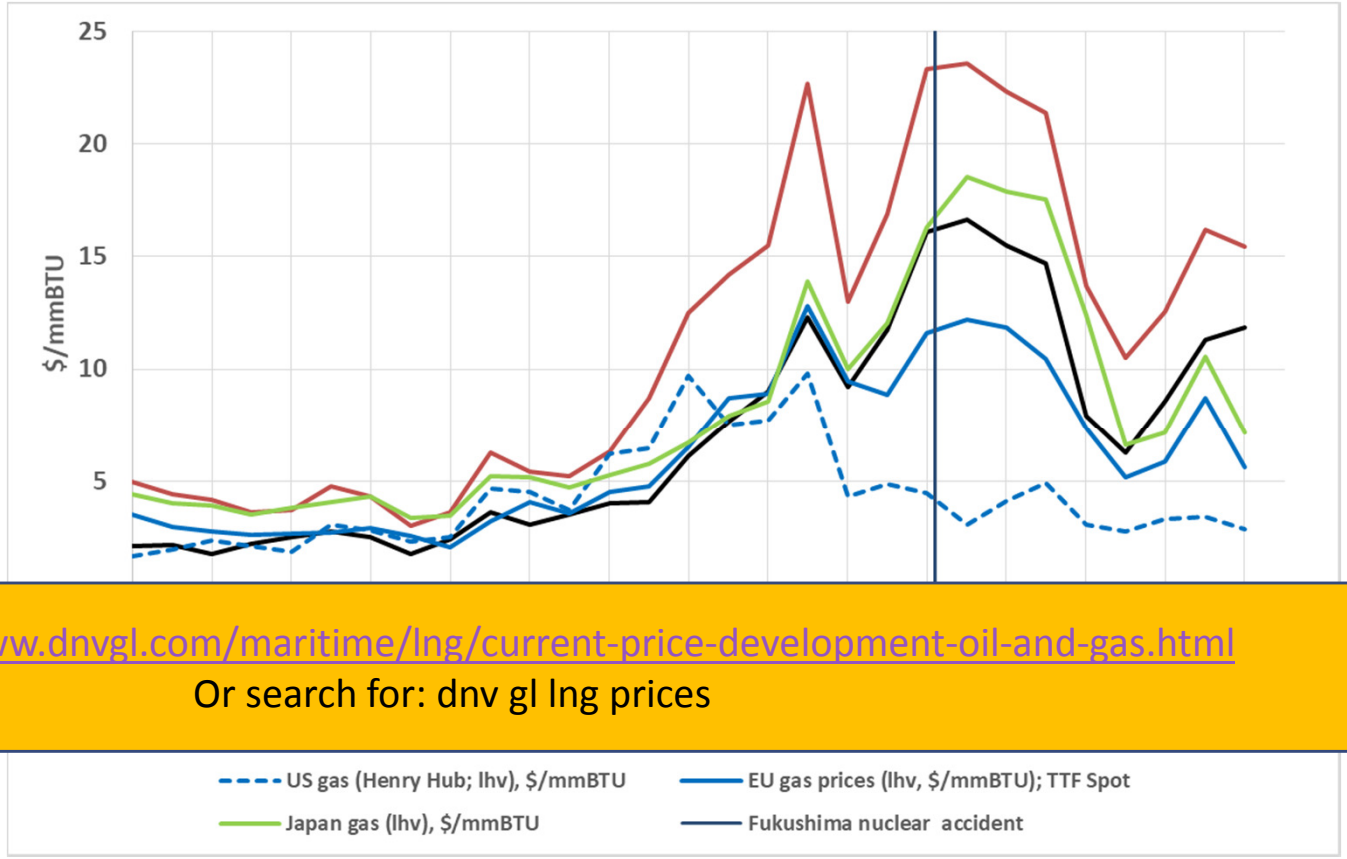
In contrast, the use of hydrogen is expected to be limited to "a small number of smaller ships" due to high investment costs and technical constraints, according to the DNV GL's ETO.

DNV GL's environmental consultant for shipping Oyvind Endresen said ammonia would be competitive due to its price as fuel and cost of storage.

"You don't need to have large tanks [for ammonia], compared with hydrogen," Endresen said.

Energy carrier prices 1991 to today

In Europe you can not sell
LNG above pipline gas price!



Look to: https://www.dnvgl.com/maritime/lng/current-price-development-oil-and-gas.html
Or search for: dnv gl lng prices

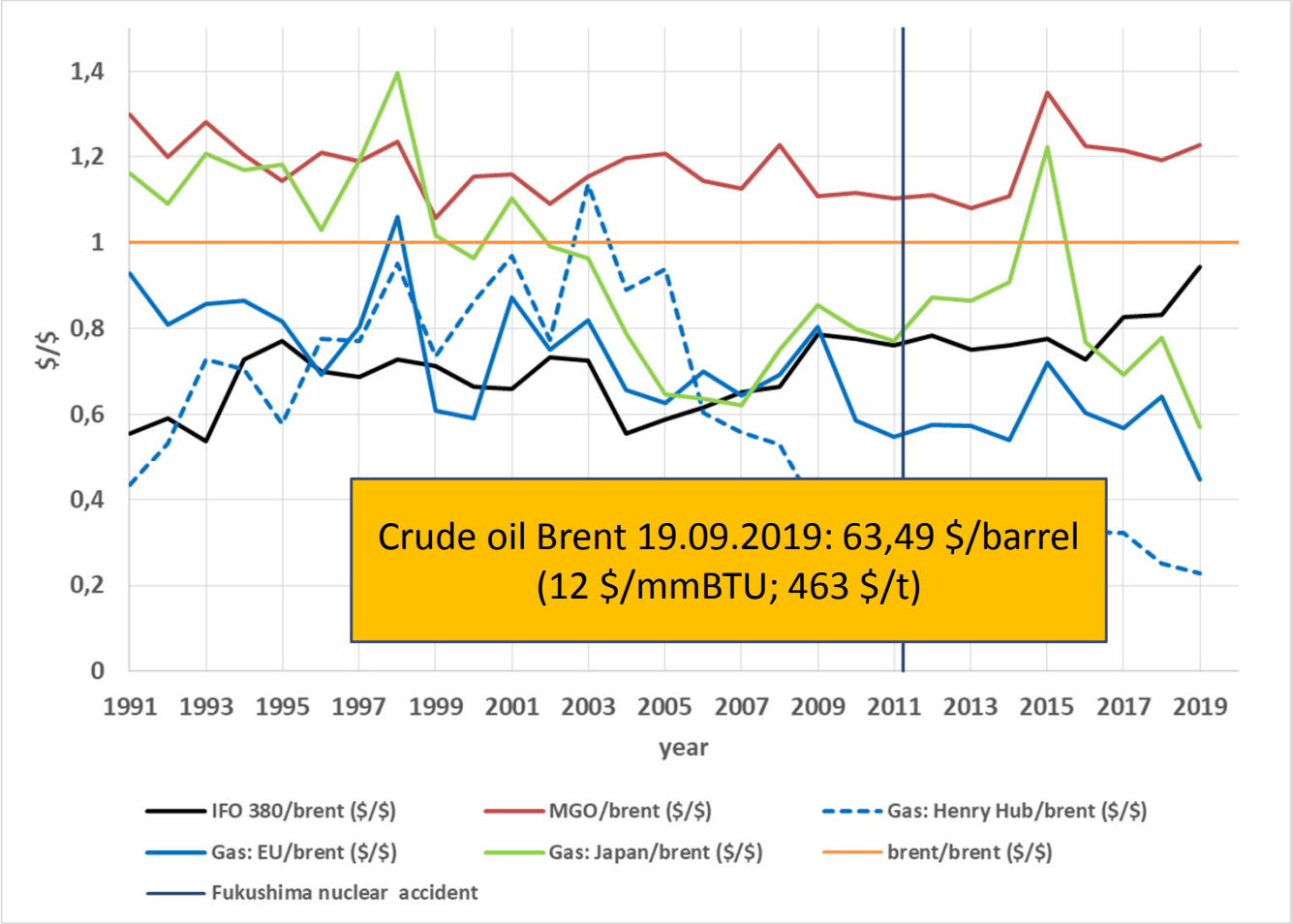
Energy carrier prices related to crude oil Brent - 1991 to today -

MGO prices are always above crude Brent

Gas prices in Europe and Japan come closer

HFO price is increasing

Gas prices in US are low → export of US LNG



Basic assumptions for this presentation

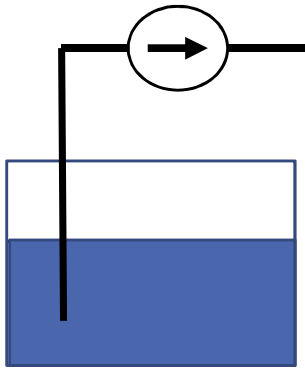
- The **world takes** their **CO2 reduction** targets **serious** (Paris agreement, IMO targets).
- The **OECD countries** manage to **keep a relevant industrial base and economic welfare.**
  - There is a **need for large scale import** of **renewable energy** to these countries.
  - **Beyond 2040** the import of renewable energy will largely be **based on PtX**.
- Overall the **people** on earth **get a better life** than they have today and the population grows further
  - The **need for energy** and resources is **not shrinking**.
  - The **need for transport** is **not shrinking**.
- It is **not possible to met the IMO CO2 targets** for shipping **by newbuilding alone**.
  - The **fleet in service must cover** a part of the **CO2 reduction**.
- **Shipping and aircraft** are forced to **take a share in CO2 reduction** even if their contribution stays marginal beyond 2040.
  - A switch in fuel towards **PtX is unavoidable**.
  - **Shipping** comes soon on the worlds agenda as a **consumer of PtX**.
- It is **not possible** to meet the **2°C target**.
  - **fossil fuels are relevant beyond 2050**.

A reminder for those who missed **all** their chemistry lessons in school

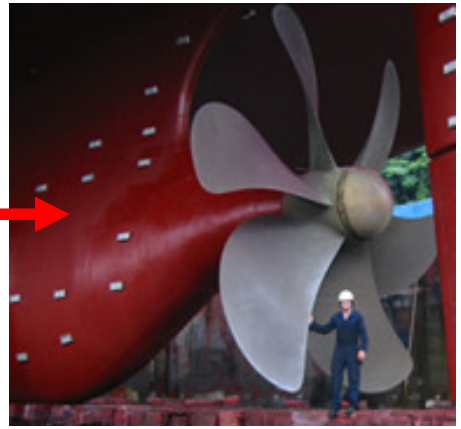
Name	Molecule
Hydrogen	H2
Methane	CH4
MGO, HFO	C10H22
Methanol	CH3OH
Ammonia	NH3

C10H22 (n-decan) used as model molecule for MGO and HFO

The two parts of CO2 emissions



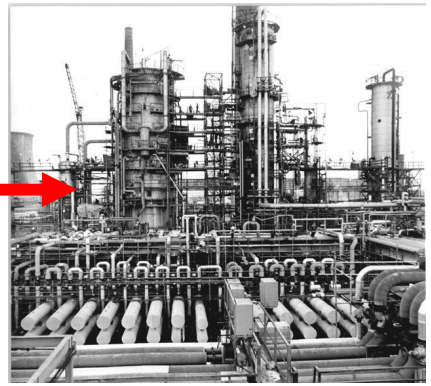
Solar Turbines



wikipedia

TTP=Tank To Propeller

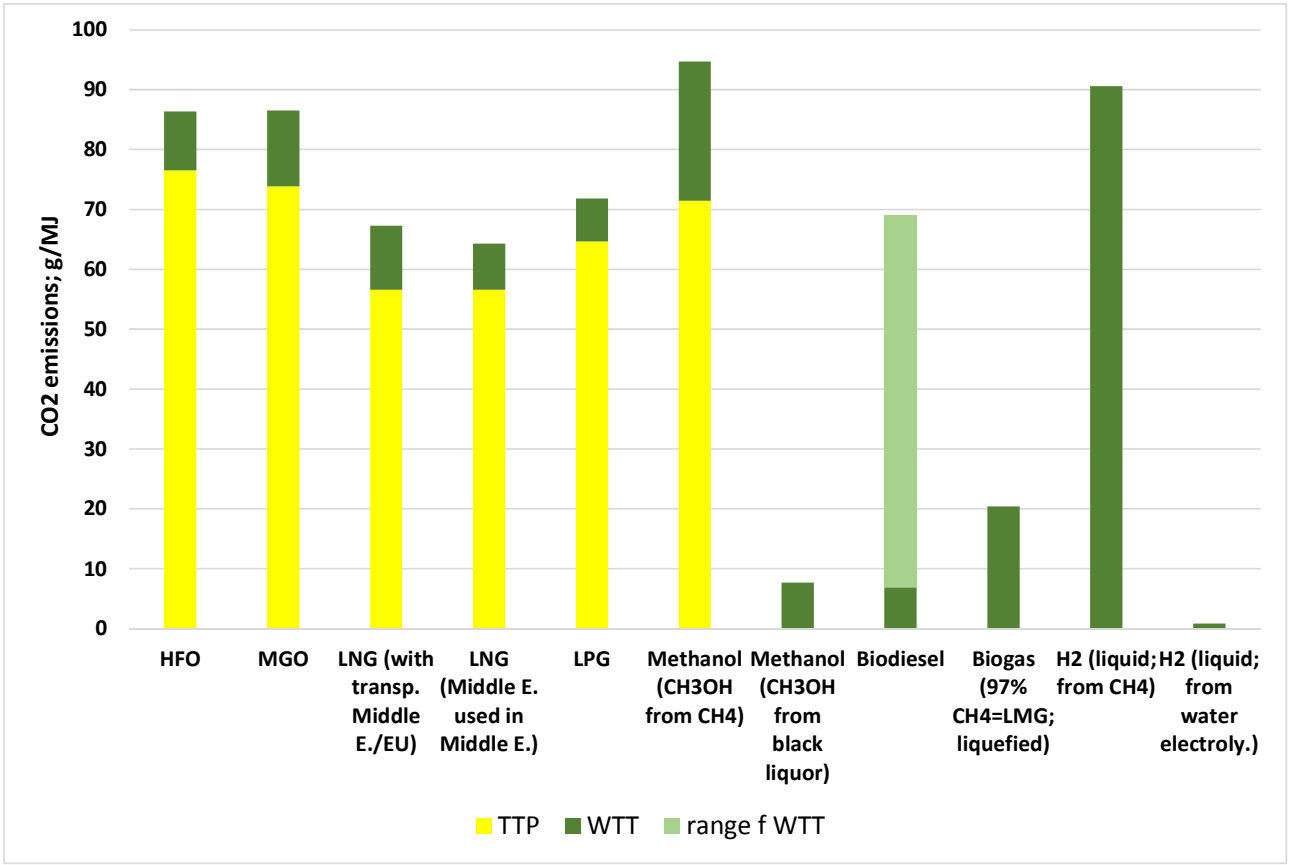
wikipedia



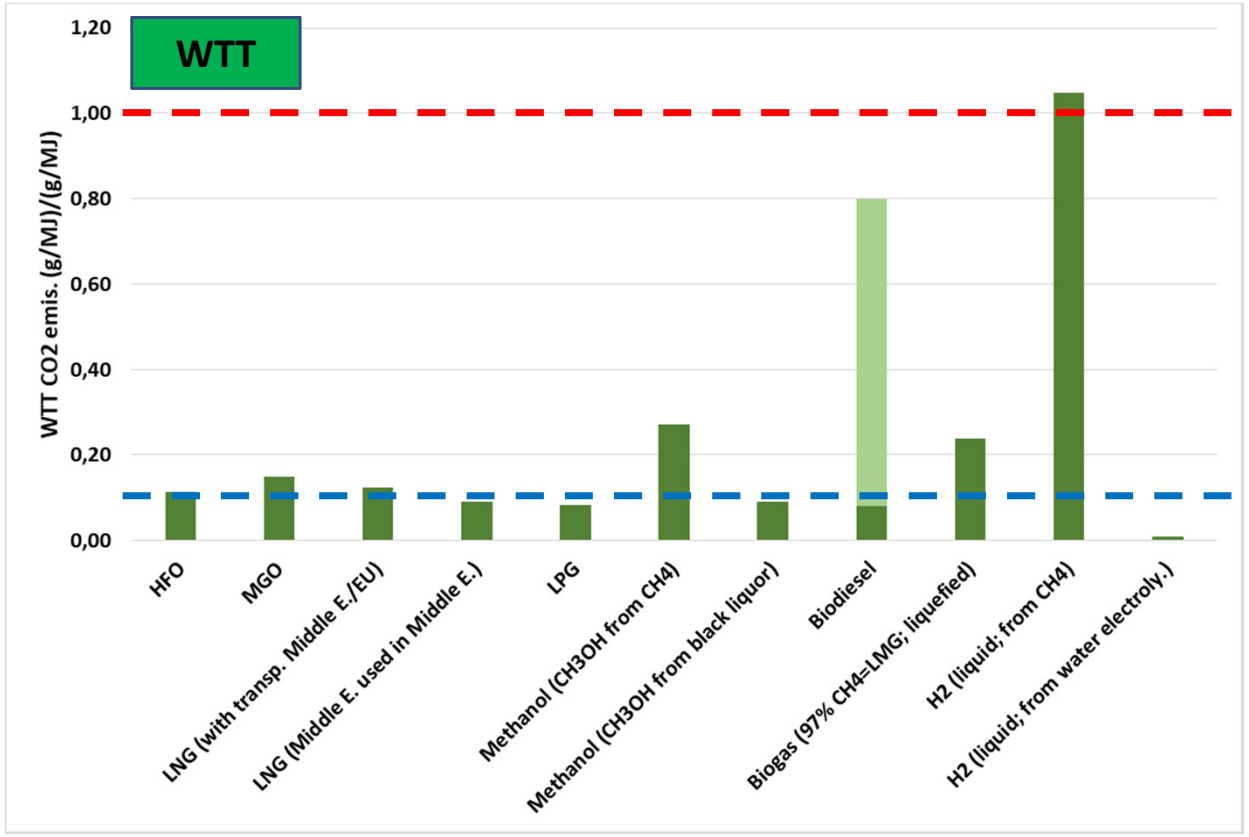
wikipedia

WTT=Well To Tank

Well to Tank and Tank To Propeller CO2-emissions of possible ship fuels



Minimum reduction potential of Power to X fuels (PtX)



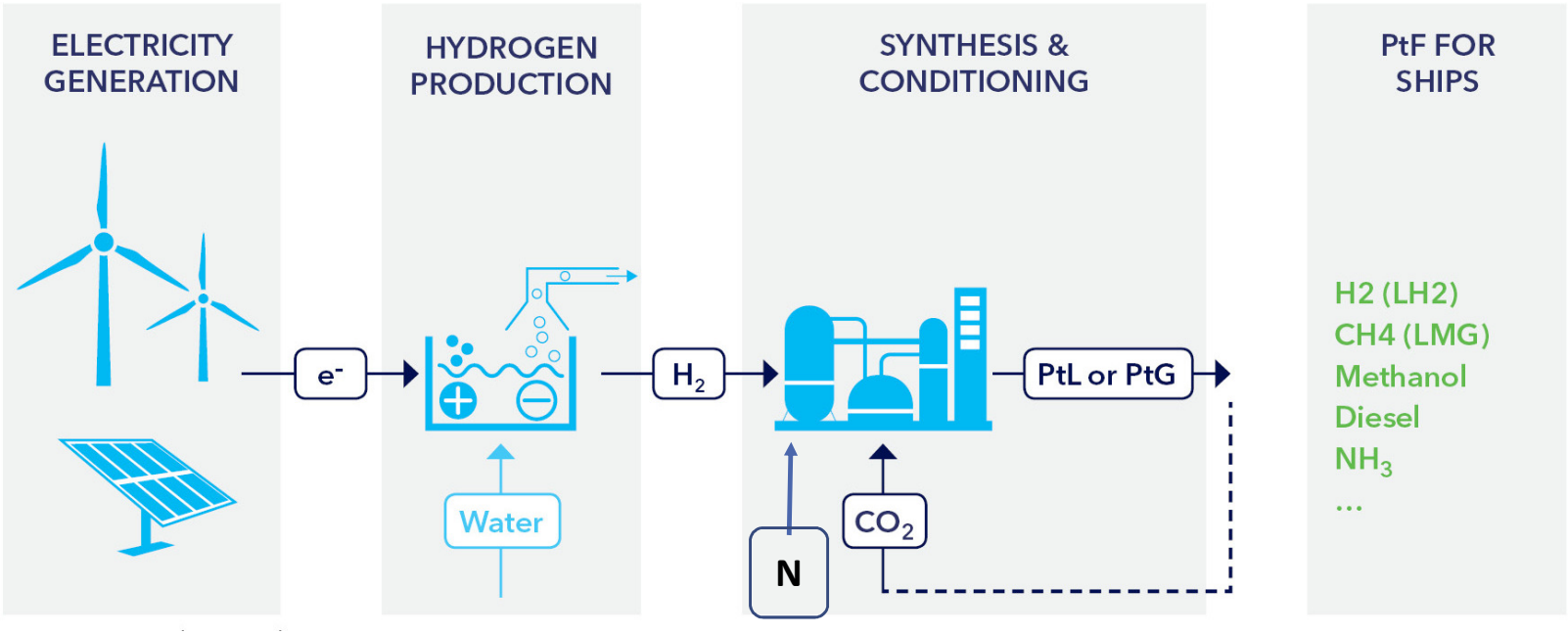
TTP+WTT emiss. of HFO

Estimated maximum for WTT emissions of PtX fuels

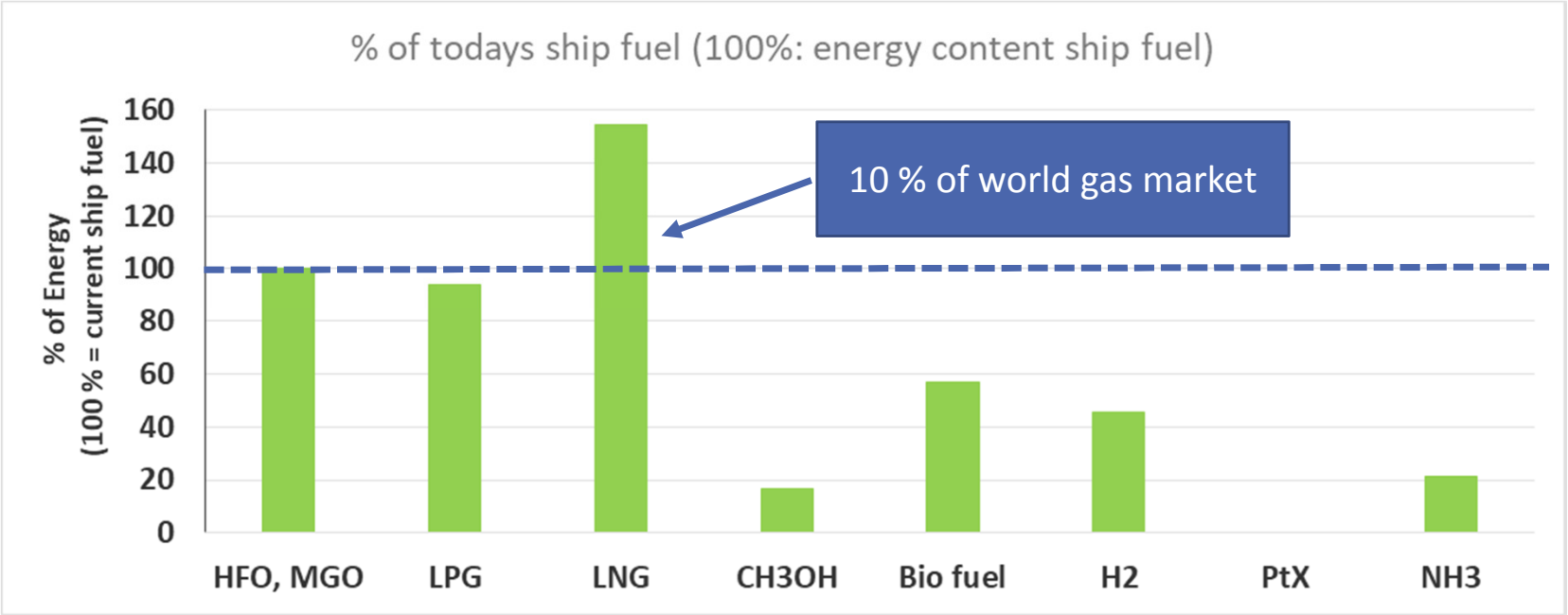
- PtX fuels have a CO2 reduction potential of at least 90% of the HFO Tank to Propeller emissions
- Well to Tank (WTT) emissions of PtX fuels will be below the WTT emissions of their fossil twins

Hydrogen (H2) is the base for all PtX fuels

Power to X production principled



What is the availability of ship fuel alternatives today ?

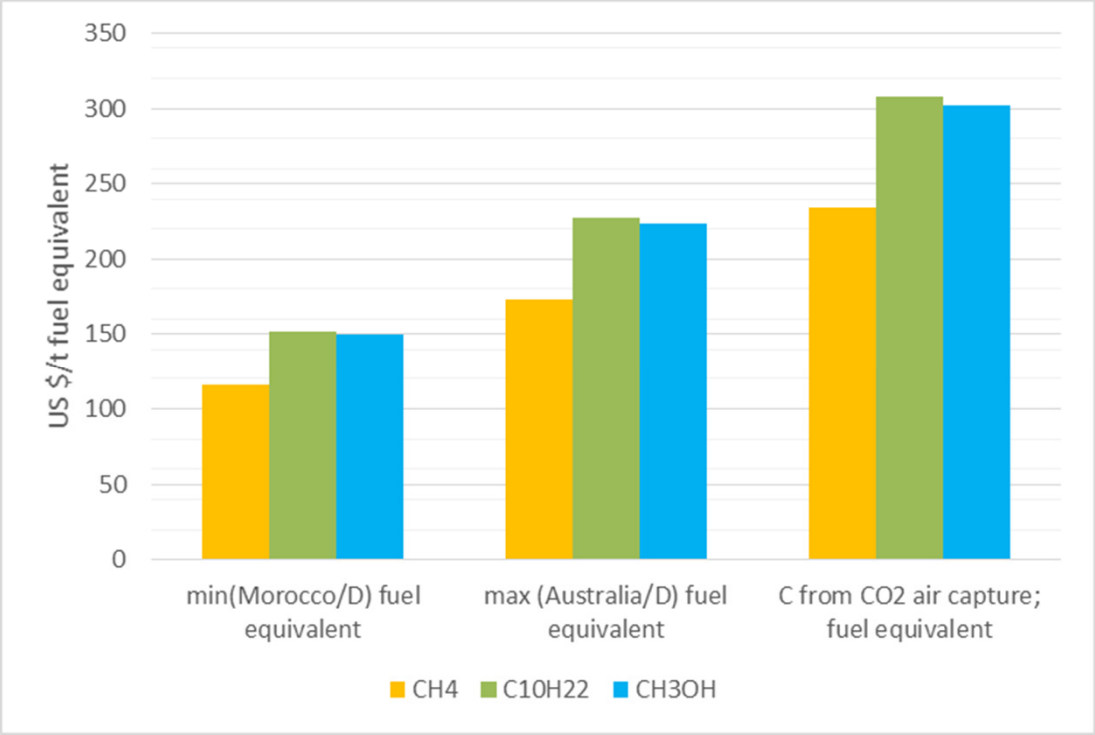


HFO,MGO	assumed consumption 2020 (330 Mio t/a)
LPG	production in 2015
LNG	production capacity end 2018 (approx. 10% of natural gas production)

CH3OH (Methanol)	production capacity 2016
Bio fuel	production 2016 (Bio Diesel and straight vegetable oil)
H2	production 2016
PtX	Power to Liquid and Power to Gas: CO2+H2 --> fuel

The share of CO2 source on PtoX costs

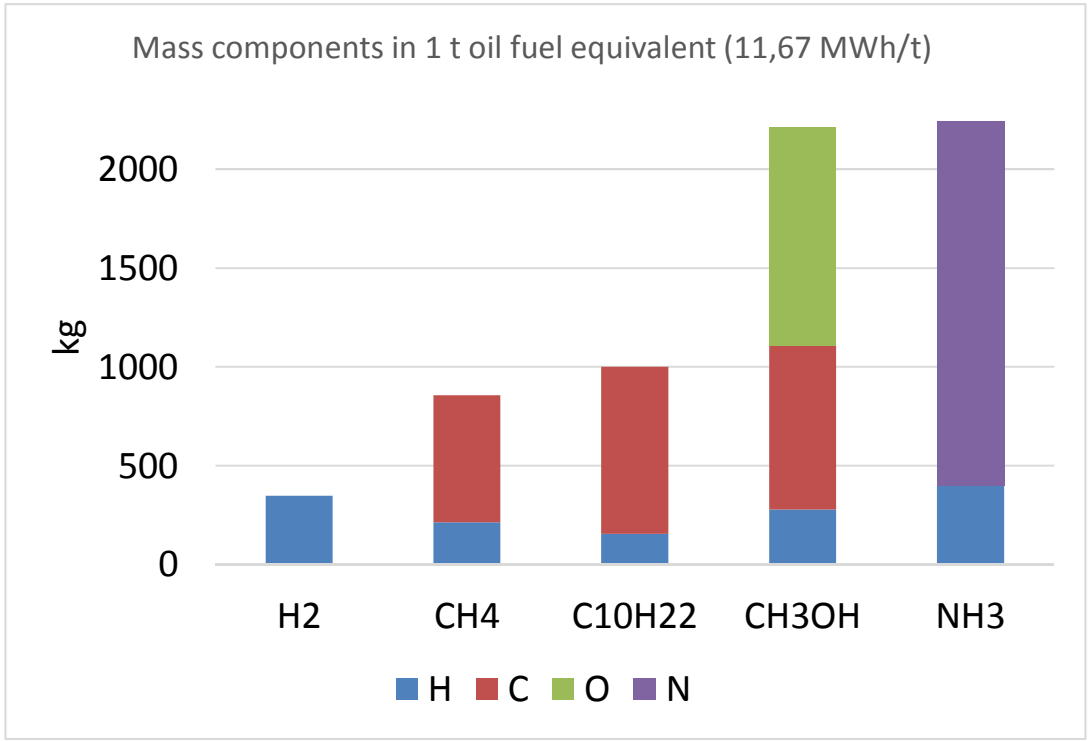
- Reference fuel: MGO with LHV=11,7 kWh/kg
- Transport costs for round trip considered
  - Morocco/D: 7 $/t CO2
  - Australia/D: 45 $/t CO2
- Assumed costs for CO2 separation: min 77 US$/t, max 116 US$/t
- Assumed costs for CO2 from Air: 156 $/t (Source: DENA)



Water costs: 10 $/m**3 would be 1 US $ct/kg H2! → not considered

Mass composition for the energy equivalent of 1 t oil fuel (11,67 MWh/t)

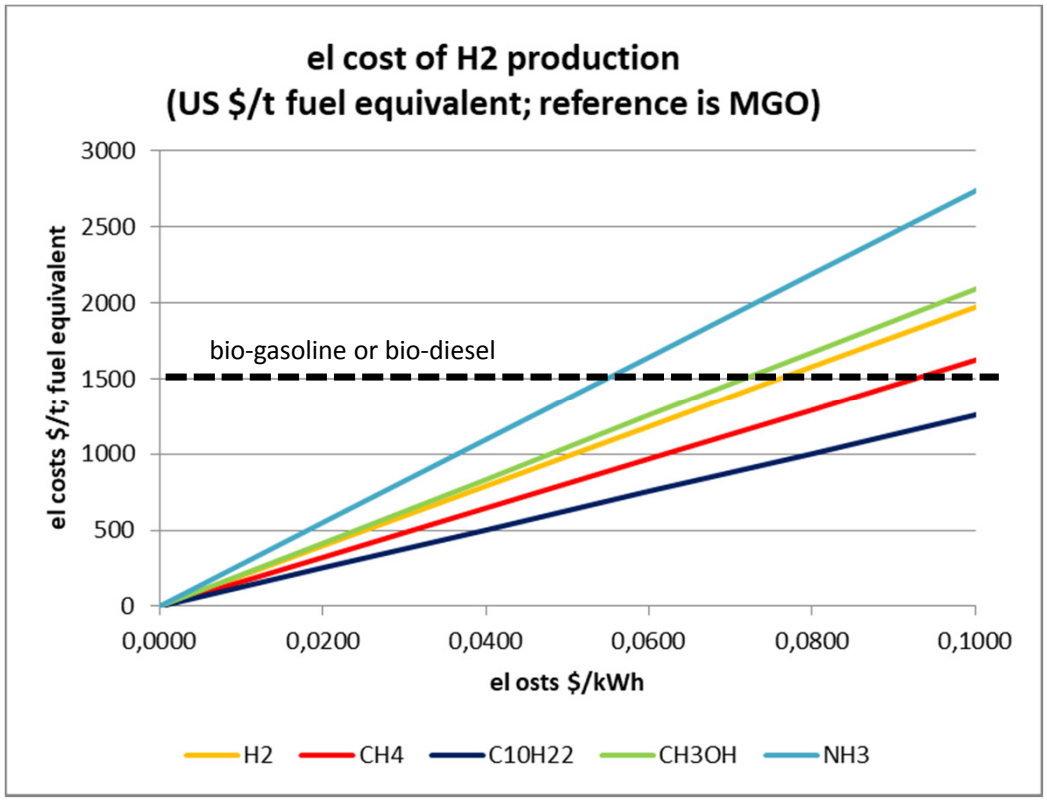
- Ships need energy not tons of fuel!
  - Only the hydrogen needed for a given energy is relevant **not the hydrogen per ton**



Electricity costs for the hydrogen production for PtX with fuel equivalence to MGO

	Molecule	LHV [MJ/kg]	conversion factor to fuel equivalence	H2 content [kg/kg]	C content [kg/kg]
Hydrogen	H2	120	2,86	1,00	0,00
Methane	CH4	49	1,17	0,25	0,75
MGO	C10H22	43	1,00	0,16	0,84
Methanol	CH3OH	23	0,54	0,13	0,37
Ammonia	NH3	22	0,53	0,18	0,00

1 kg H2 has the same energy as 2,86 kg of MGO



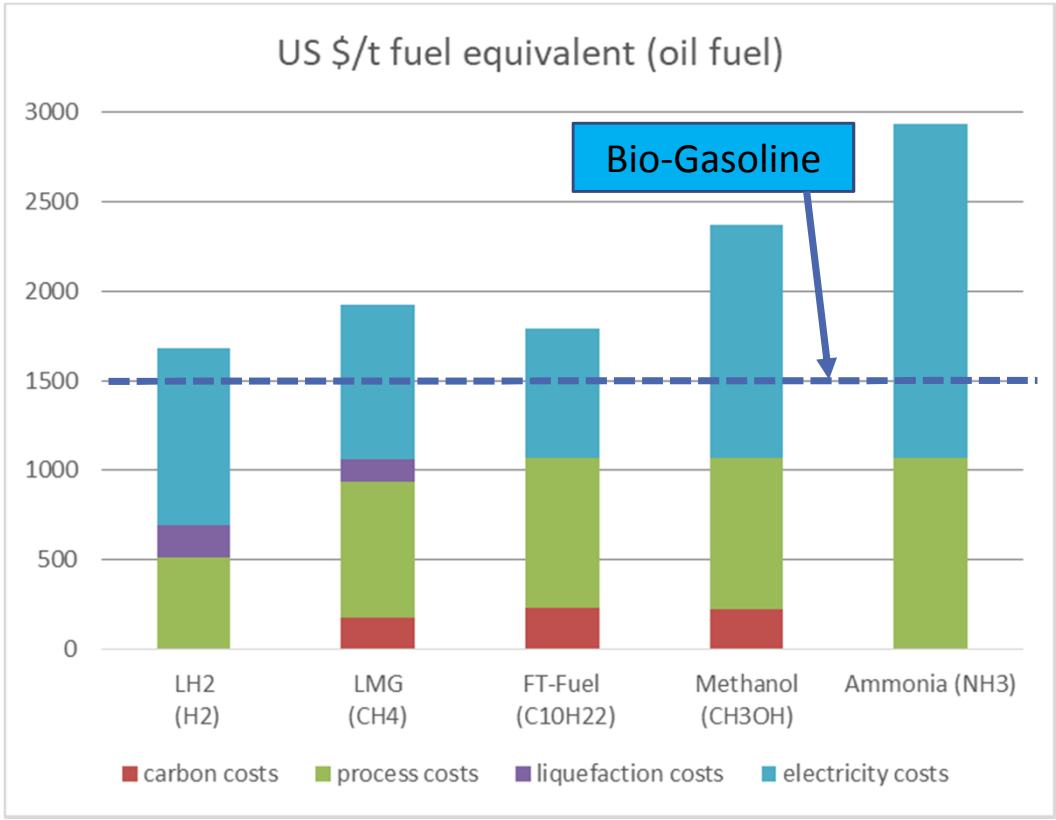
Electricity costs for the hydrogen production for 1 ton of fuel equivalent PtX

Overview for PtX costs (fuel equivalence with MGO)

Not considering the practical hurdles, **Bio-gasoline** and **LH2** are the **winners** among the PtX fuels.

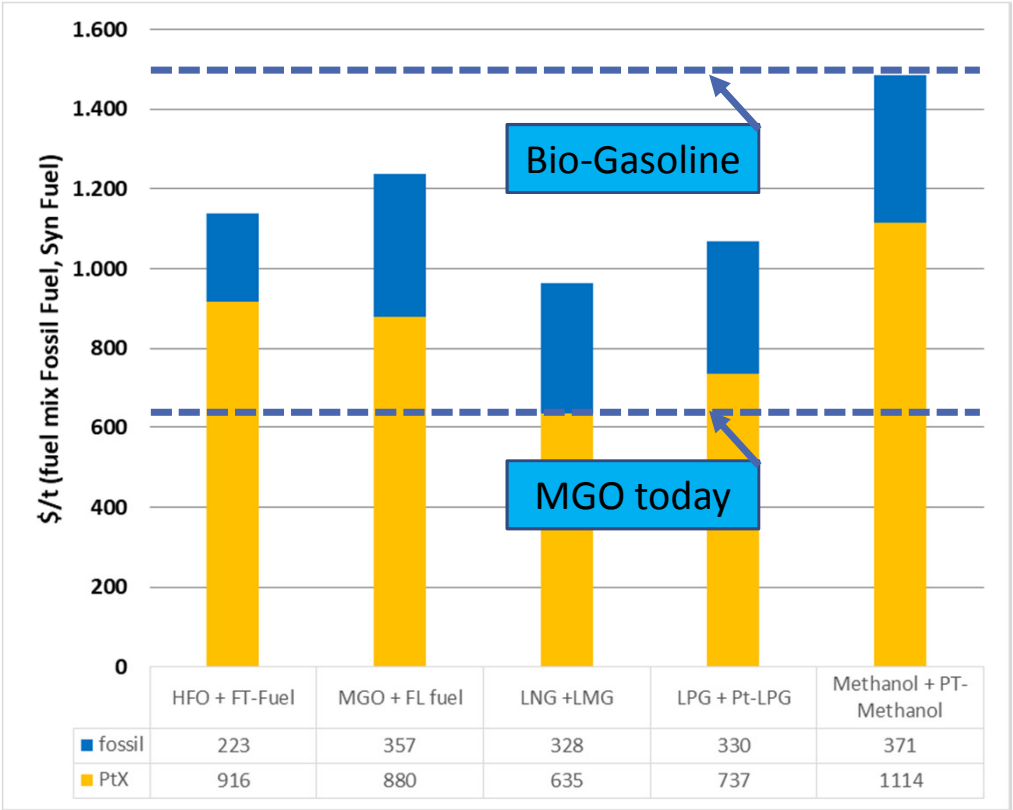
From the **cost point** of view the **race for FT Fuels** (Diesel) and **LMG** (Liquefied Methane Gas) seems **open**.

At the **upper end of cost** this is the same for **Methanol and Ammonia**.



Electricity costs assumed: 0,05 US $/kWh

What does it mean to fulfil IMO 2050 target by drop in fuel only?



Target: reduce CO2 emissions by 50% of TTP emissions

Potential cost of a fuel mix between fossil fuel and synthetic fuel (50% TTP CO2 reduction, electricity costs 0,05 US$/kWh);
Data based on DENA, Brynolf (2018); LNG liquefaction costs from DENA; LPG: costs assumed to be equal to CH4 gas; electricity costs for hydrogen production: 0,05 US$/kWh

My outlook for fuel supply in deep sea shipping

	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
LNG													
LMG													
LPG													
CH3OH													
Bio Fuel													
PtF (PtG, PtL)													
H2													
HFO													
MGO/LSHFOs													

Gerd Wuersig's 100. birthday

Kilian Wuersig's 64. birthday

Gerd's grandchildren? Younger than 39!

	2030	2040	2050	2060	2070	2080	2090	2100
LNG								
LMG								
LPG								
CH3OH								
Bio Fuel								
PtF (PtG, PtL)								
H2								
HFO								
MGO/LSHFOs								

- HFO phased out over time
- MGO and may be LSHFO survive the decade
- LNG is increasingly used and solely substituted by LMG
- LPG may be used also
- Hydrogen plays no role and a minor role beyond 2030
- PtF+PtL (includes LMG) starts to be market relevant at the end of the decade
- Methanol and Biofuel may play a role

most relevant	highly relevant	relevant	minor relevance	not relevant	no interest

Thank you for your attention

GMW Consultancy

– Marine-, Process, Energy Technology -

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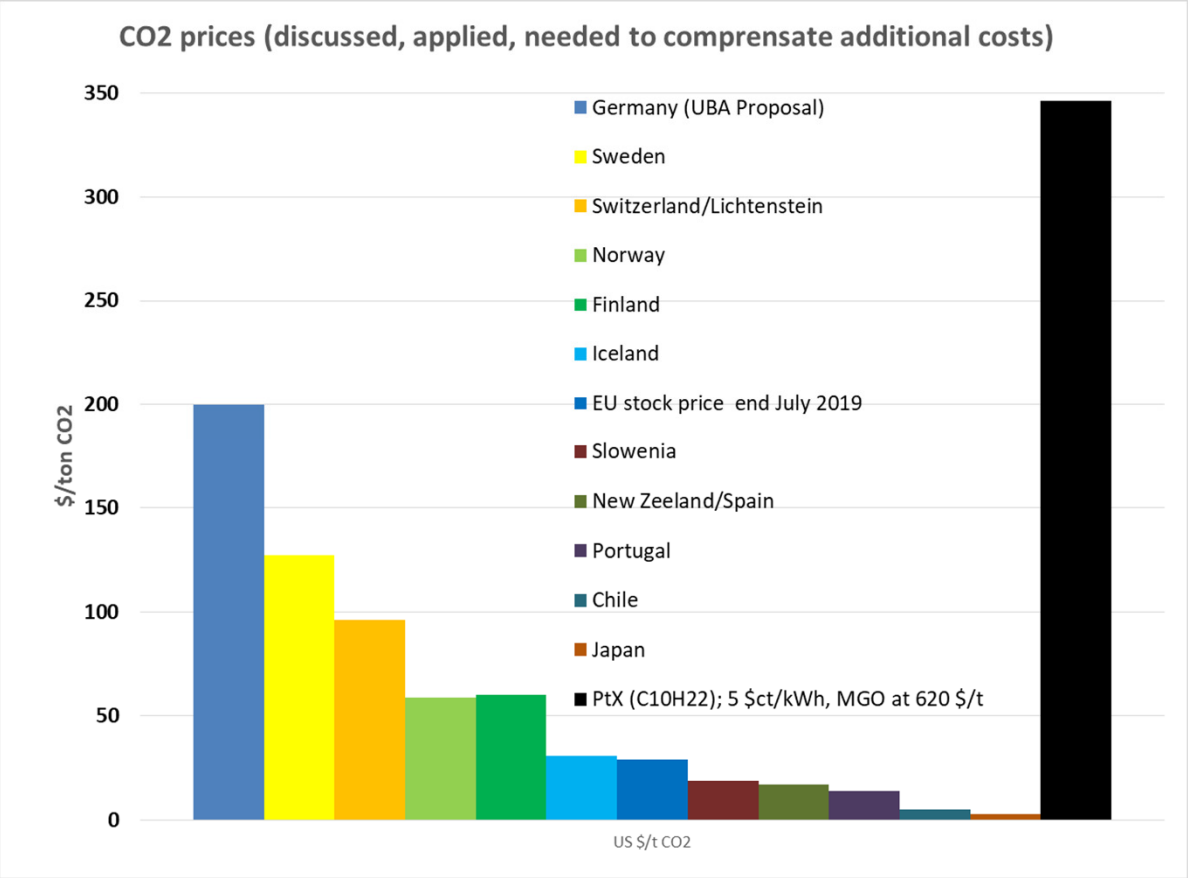
The costs which need to be covered



Source: VDI Nachrichten S. 21, Nr 34 (2019), 23 August; PtX (LH2) own data