Alternative Kraftstoffe in der Schifffahrt
- WWW(Wann? Was? Wie teuer?) -

Dr.-Ing. Gerd Wuersig

GMW Consultancy

- Marine-, Process-, Energy Technology -

Dr. Gerd Wuersig and GMW Consultancy

- GMW Consultancy founded 2019 by Dr. Gerd Wuersig.
- Process and energy engineer
  - long term experience in shipping
  - GMW Consultancy offer independent consultancy to the stakeholders in shipping like owners, suppliers, yards, NGOs and authorities (comp. www.GMW-Consultancy.com).
- Professional experiences related to engineering advisory services, research & development, business development, process-, gas-, safety- and fuel cell technology.
- Long term Involvement in liquefied gas technology
  - doctorial work on the development of a liquefied hydrogen sea transport system in the early 90ies.
- Since the 90ies and until 2013:
  - contributed as a consultant for the German ministry of transport to IMO work on IGC-Code (IMO Code for Gas Carriers) amendments, development of the new IGC-Code and the development of the IGF Code (IMO Code for ships with low flashpoint fuels).
  - still contribution to the German mirror group on IGF-Code development.
- Until 2019 representation of GL, DNV and DNV GL at SIGTTO and SGMF
- Contribution to different ISO working groups.
- Member of the SGMF Technical Committee and the Environmental Committee.
- Participation in the development of the ISO and SGMF LNG bunkering requirements, SIGTTO work on LNG fires around gas carriers.
- Since early 90ies: active member of the process technology safety working group of the German chemical engineers society (DECHEMA).
- Active member of VSM, STG, VDI, DECHEMA.

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- W = Wann? -

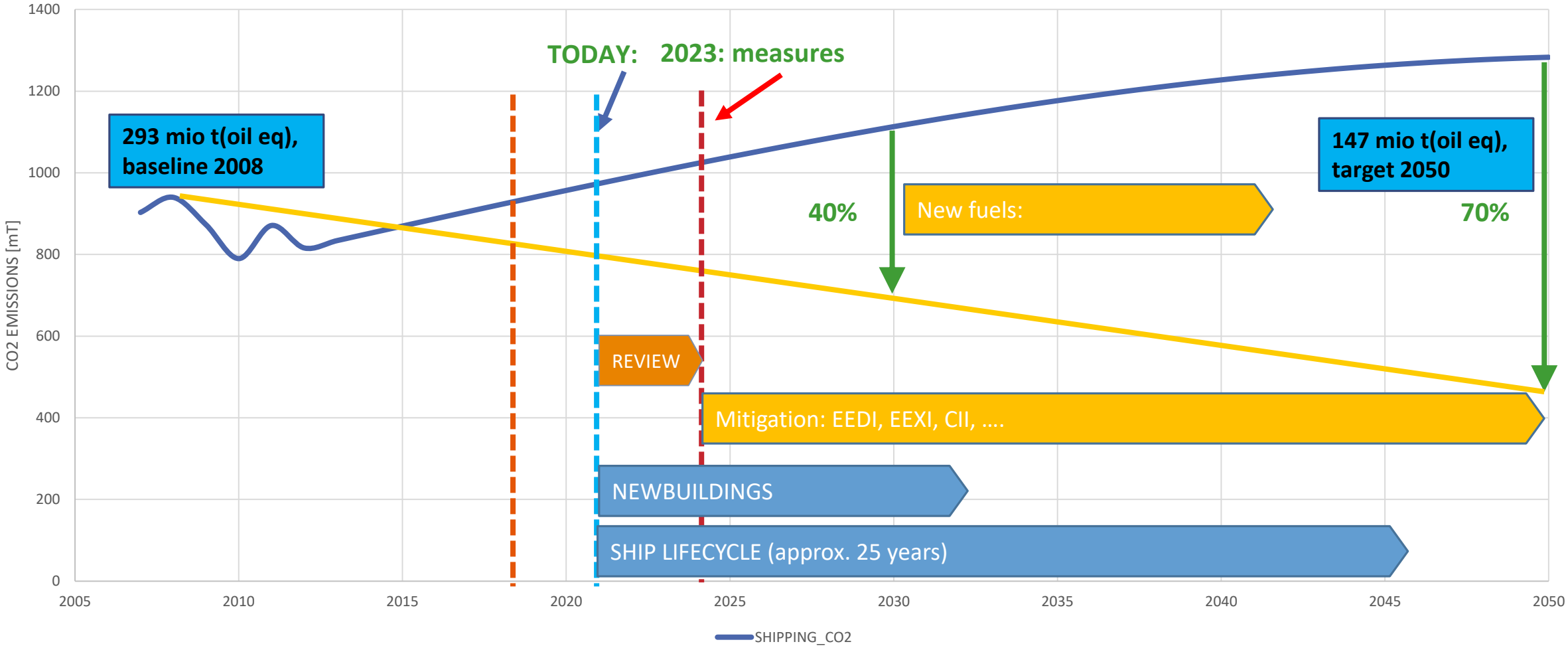
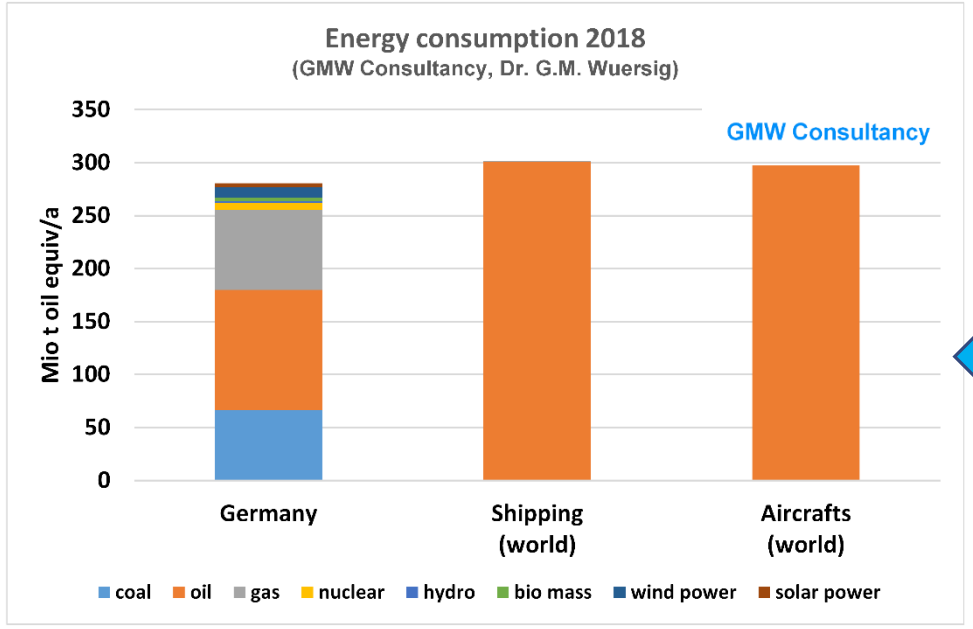
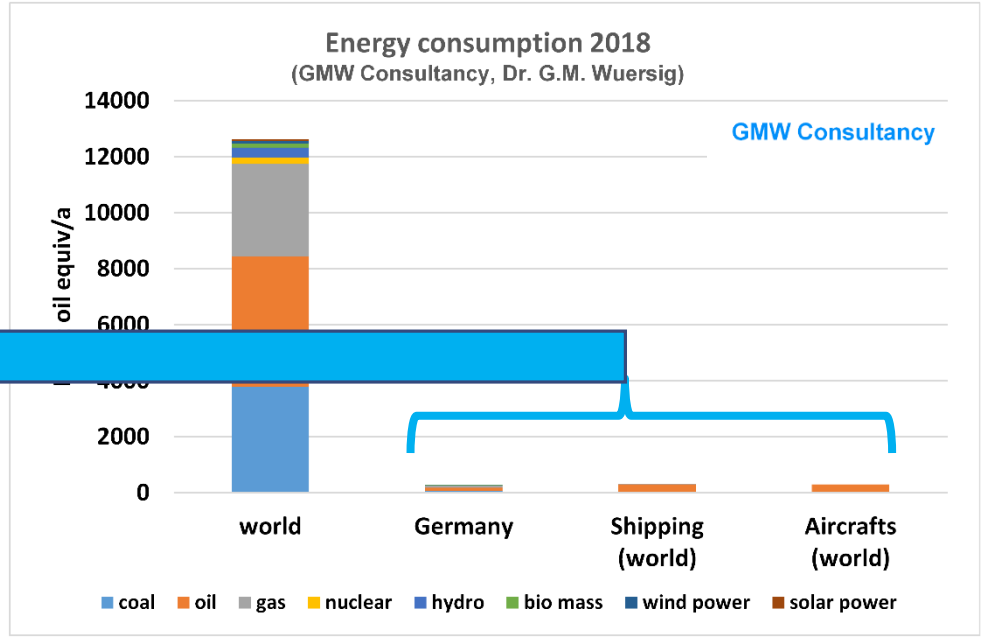


Figure derived from first version developed by Malte Zeretzke 2018 at DNV-GL

The scope of the problem and the 2 % Club





- Shipping and aviation are two sectors difficult to decarbonize.
- The energy consumption is approximately the same as the energy consumption of Germany. Together they are “The 2 % club”
- On the overall path toward zero CO2 emissions the absolute contribution of the 2% club is small . But:
  - In a e.g. 90% decarbonized energy world a non carbonization of the 3% Club would give it the majority of all remaining CO2 emissions

  → **the 3 % Club has to take it’s share!**

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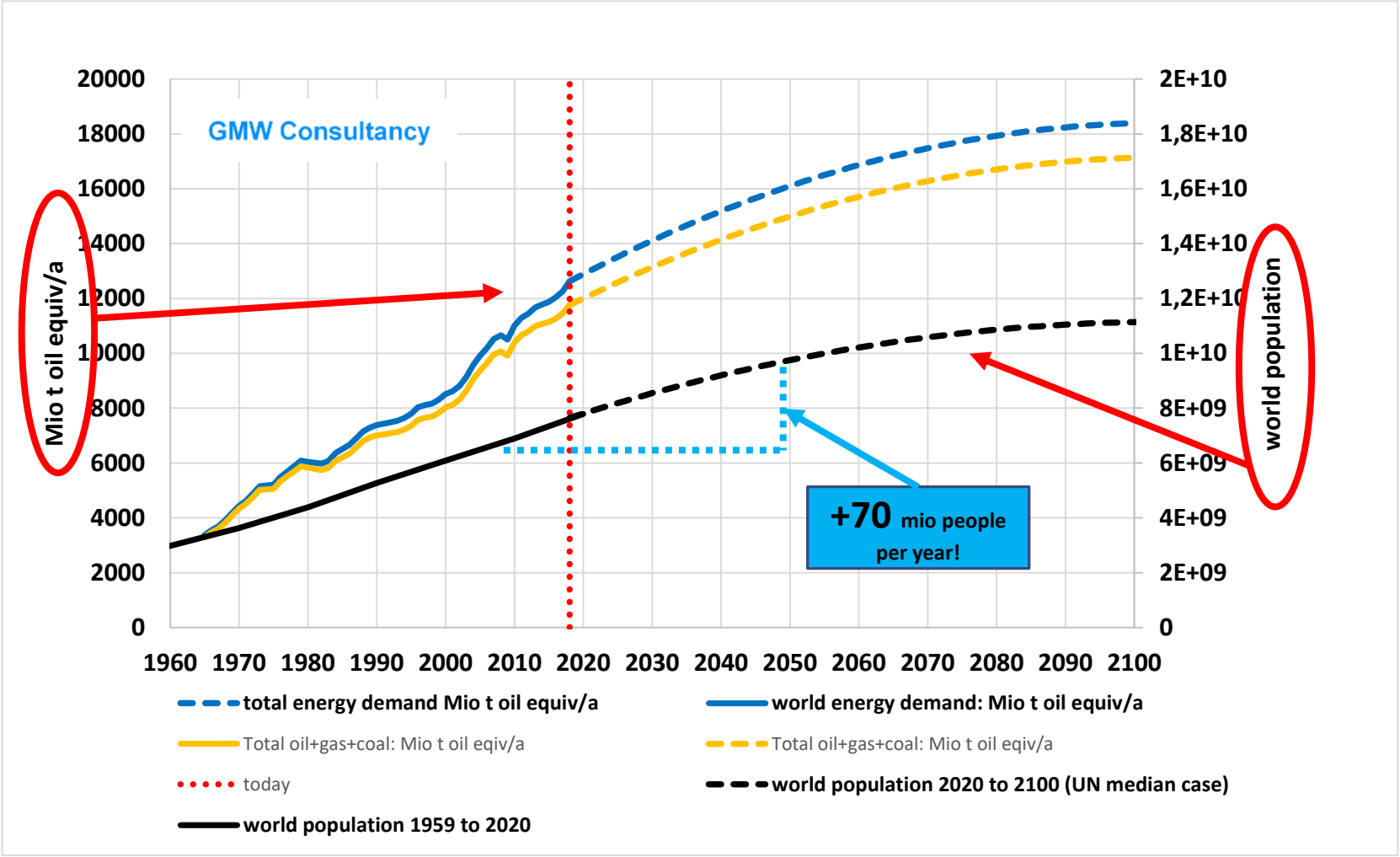
The scope of the problem

- World population growth by 70 mio per year between and 2050.
- For this reason alone an increase in energy demand is more than likely.
- The 1,5° aim for GHG requires:
  - to cover the growing demand without fossil fuels.
  - To reduce the use of coal, oil and gas dramatically.



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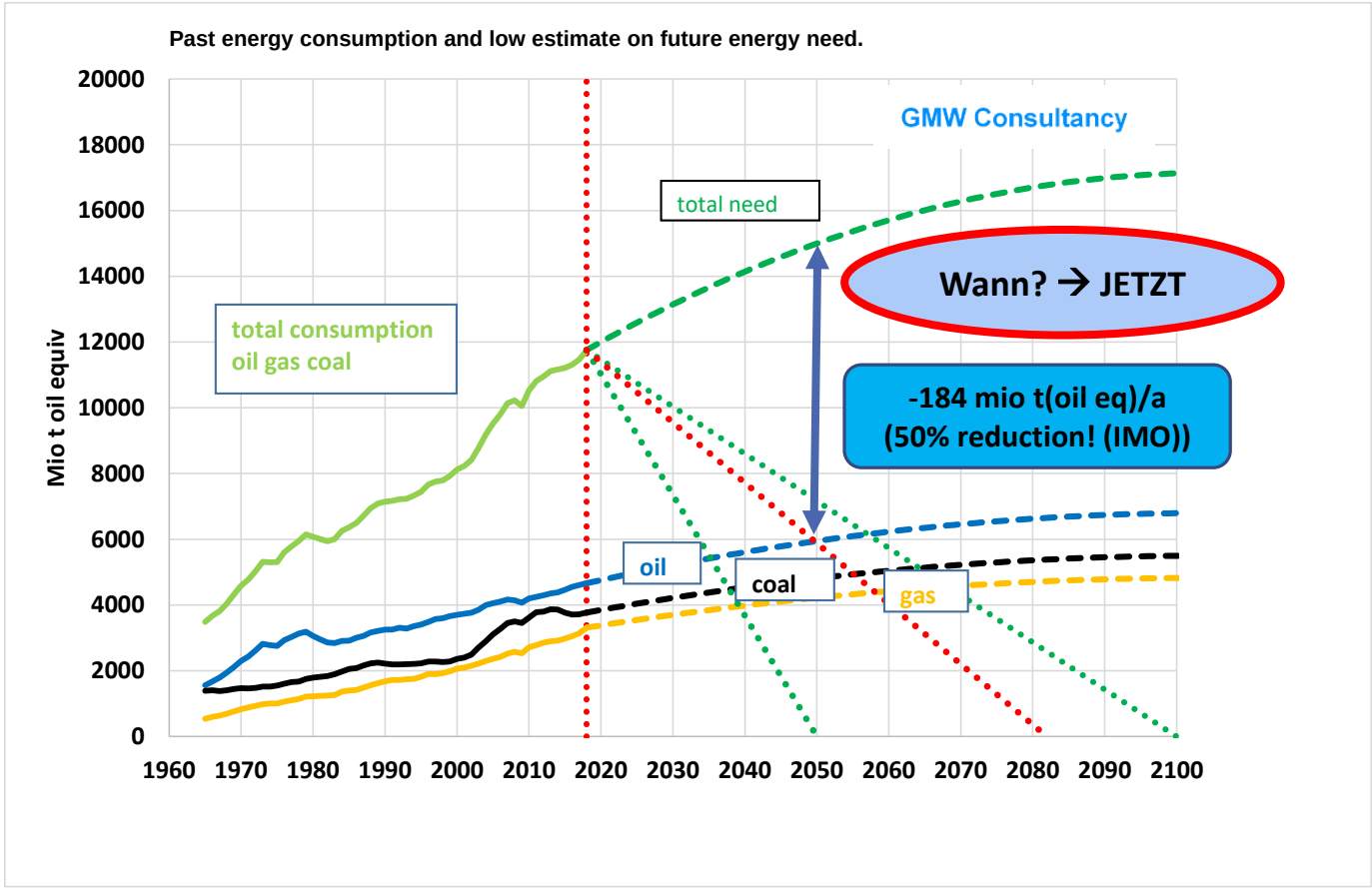
The 50% reduction target compared to current an past ambitions.

- To reach only 50 % reduction in fossil fuel use until 2050 requires:
  - a reduction equal to 184 mio t of oil equivalent every year.
  - A substitution by CO2 free or neutral energy of 184 mio t oil equivalent every year.
- Current ambitions are much higher than the 50% aim of IMO for deep sea shipping!
  - E.g. IEA: - 87% CO2 emission reduction for shipping.
    - IEA special report Mai 2021: “Net Zero by 2050 - A Roadmap for the Global Energy Sector”



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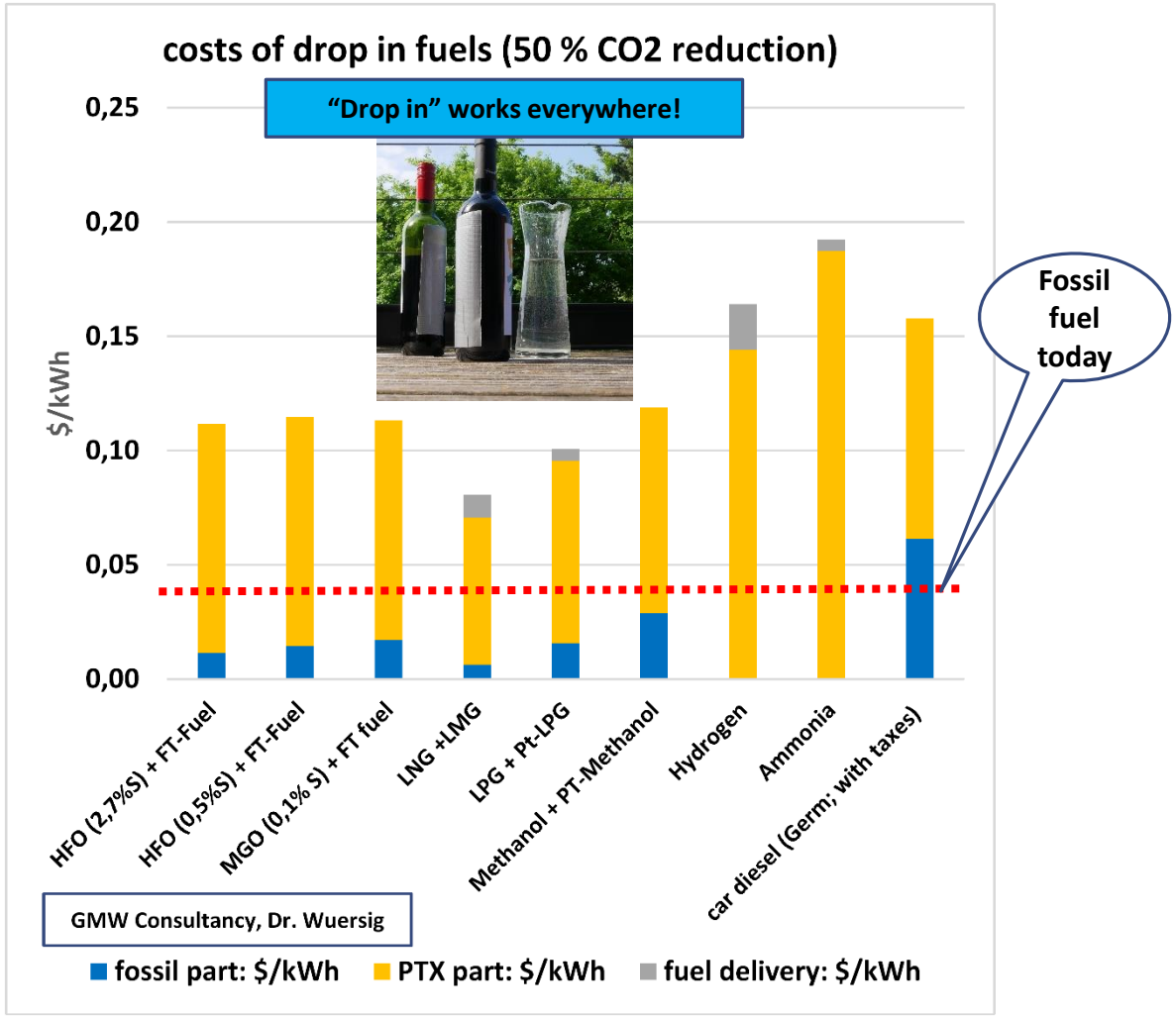
Alternative Kraftstoffe in der Schifffahrt - W = Was/Wie? -

- LNG combined with PtX LMG has clear cost advantages:
  - LNG+LMG: only 30% LMG needed to reach IMO 50% goal.
  - MGO+FT-Fuel: 50% FT-Fuel needed to reach IMO 50% goal.
- Pure PtX fuels like Ammonia or Hydrogen have cost disadvantages

Mit „drop in“ Brennstoffen ist ein Übergang eher bezahlbar als mit puren PtX Brennstoffen!



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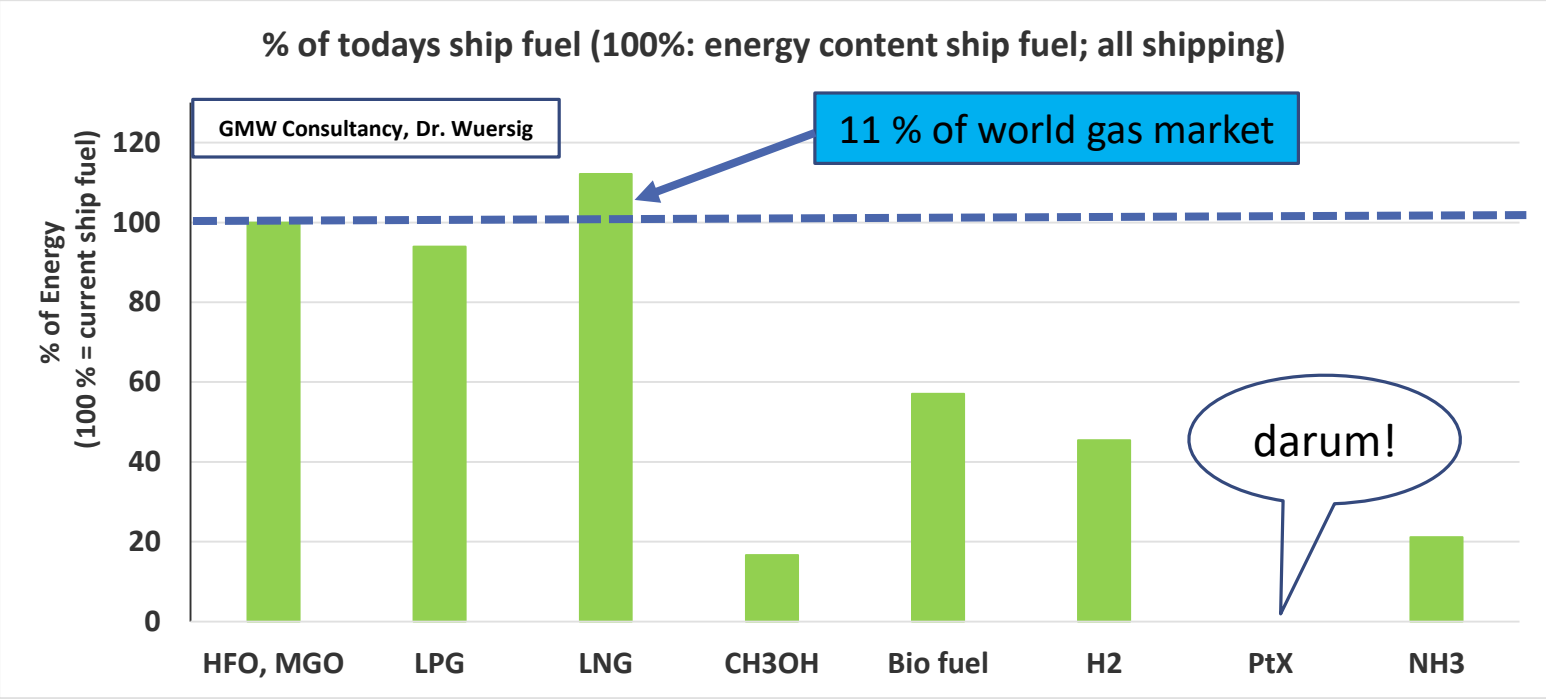
Warum nicht JETZT "klimaneutral" sein?

- There is practically no PtX production today!
  - PtX can not play a relevant role before 2030!
- LNG and to some extend LPG are the only real 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

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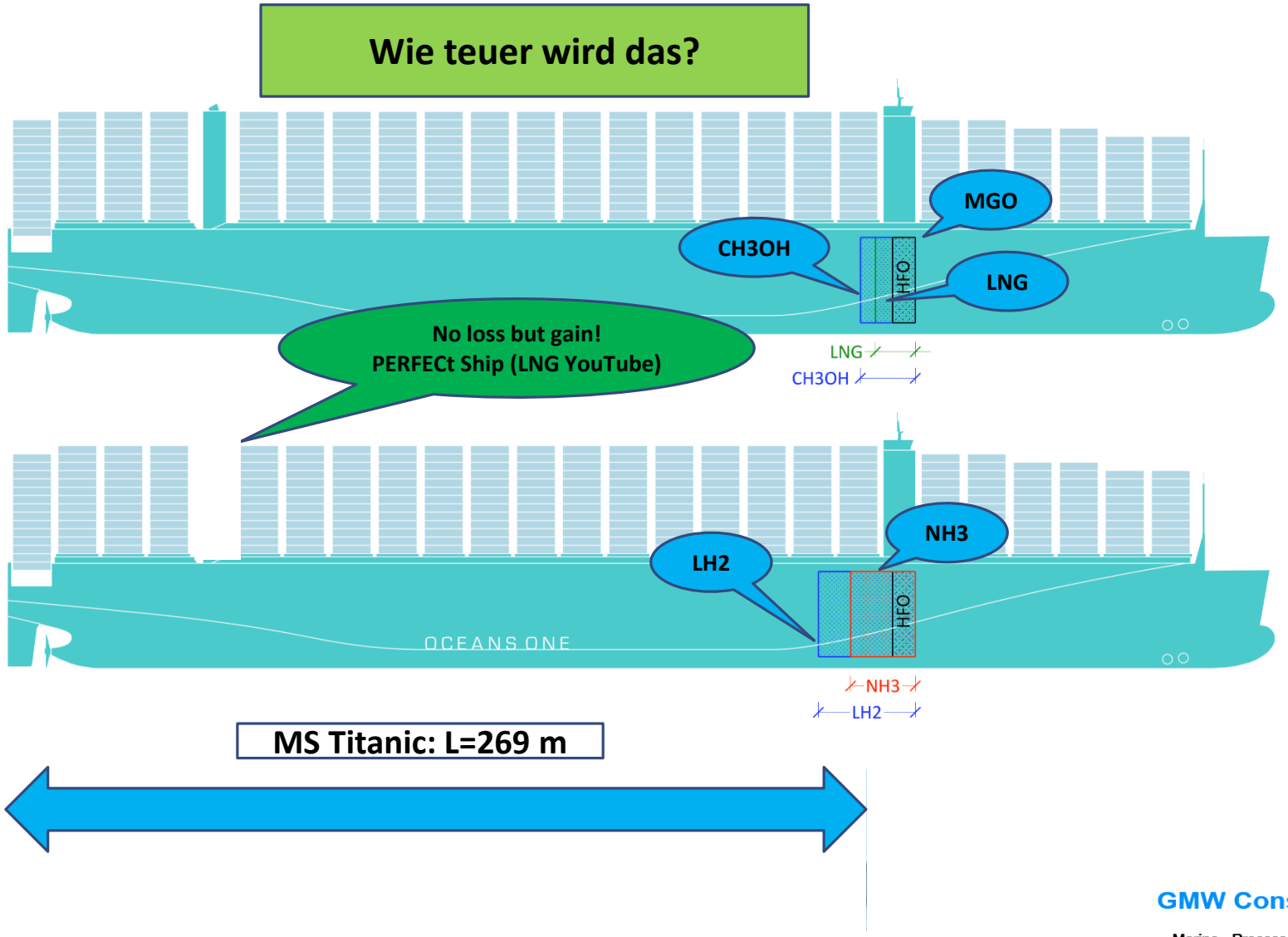
Nichts geht über die Energiedichte von Öl!
- Tankgrößen für PtX Tanks eines 24000 TEU Container Schiffes -

- 10550 m**3 MGO
  - - 0 TEU
- 18600 m**3 LNG
  - 0 bis - **576 TEU**
- 25559 m**3 CH3OH
  - - **576 TEU**
- 30158 m**3 NH3
  - - **576 TEU**
- 45142 m**3 LH2
  - - **1152 TEU**



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Morgen fahren wir alle mit Wasserstoff!
- Oder doch nicht ? -

- Transport tanks for Liquefied hydrogen have been built as
  - Containers up to 300 m**3 LH2 exist
- Ship tank installed in the test ship SUISO FRONTIER has 1.200 m**3 LH2 tank
- Developments have been done for
  - The EQHHPP Project for 3.000 m**3 Tanks (1989/1996)
    - Tank system has been tested with a 60 m**3 test tank
  - The HDW, GL project for tanks of 23.000 m**3 LH2
- Kawasaki announced a 160.000,- m**3 LH2 tanker for 2030

3000 m**3 LH are equal to 710 m** of oil!


Source: GMW Consultancy

Source: Nordseeweerke Emden

Source: TKMS


Source: Internet (Kawasaki)

Der „Stand der Technik“ in der H2 Technologie für Schiffe ist ist 25 Jahre alt aber immer (noch) deutsch

und (noch) nicht japanisch!

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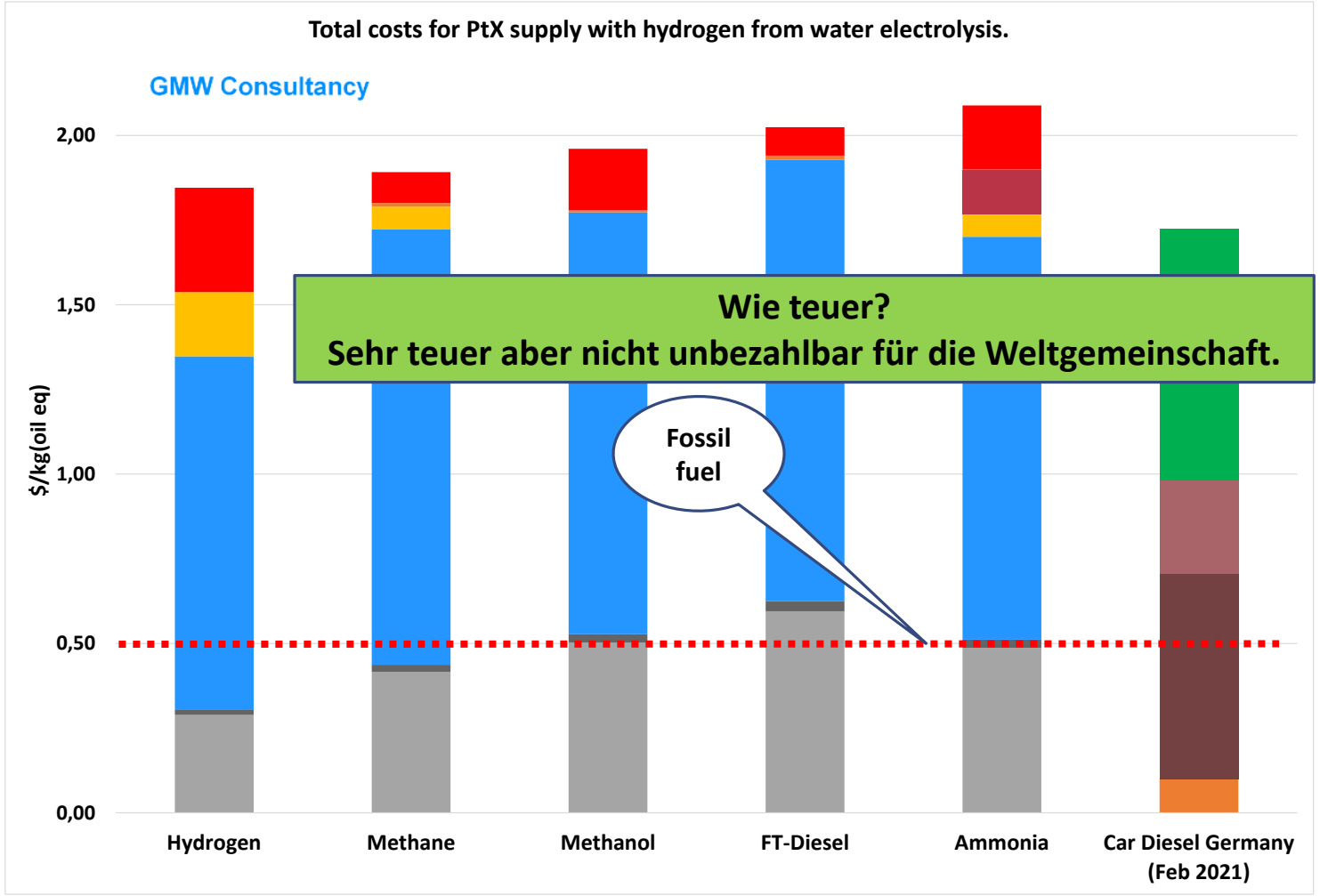
Alternative Kraftstoffe in der Schifffahrt - W = Wie teuer? -

- The production costs of PtX (Power to X) fuels are similar.
- There is no clear “winner”.
- Note: 1 kg oil is equal to approx. 12 kWh



	P	Q
94		transport costs: 10.000 sm round trip
95		nitrogen generatio (CAPEX+energy)
96		liquefation (CAPEX + energy)
97		electricity for electrolysis (0,05 $/kWh)
98		OPEX electrolyser+sysnthesis
99		CAPEX electrolyser+synthesis
100		CO2 costs (or CO2 tax (Ger))
101		taxes on Diesel in Ger
102		VAT on Diesel in Ger
103		total costs (including crude) at refinery in Ger

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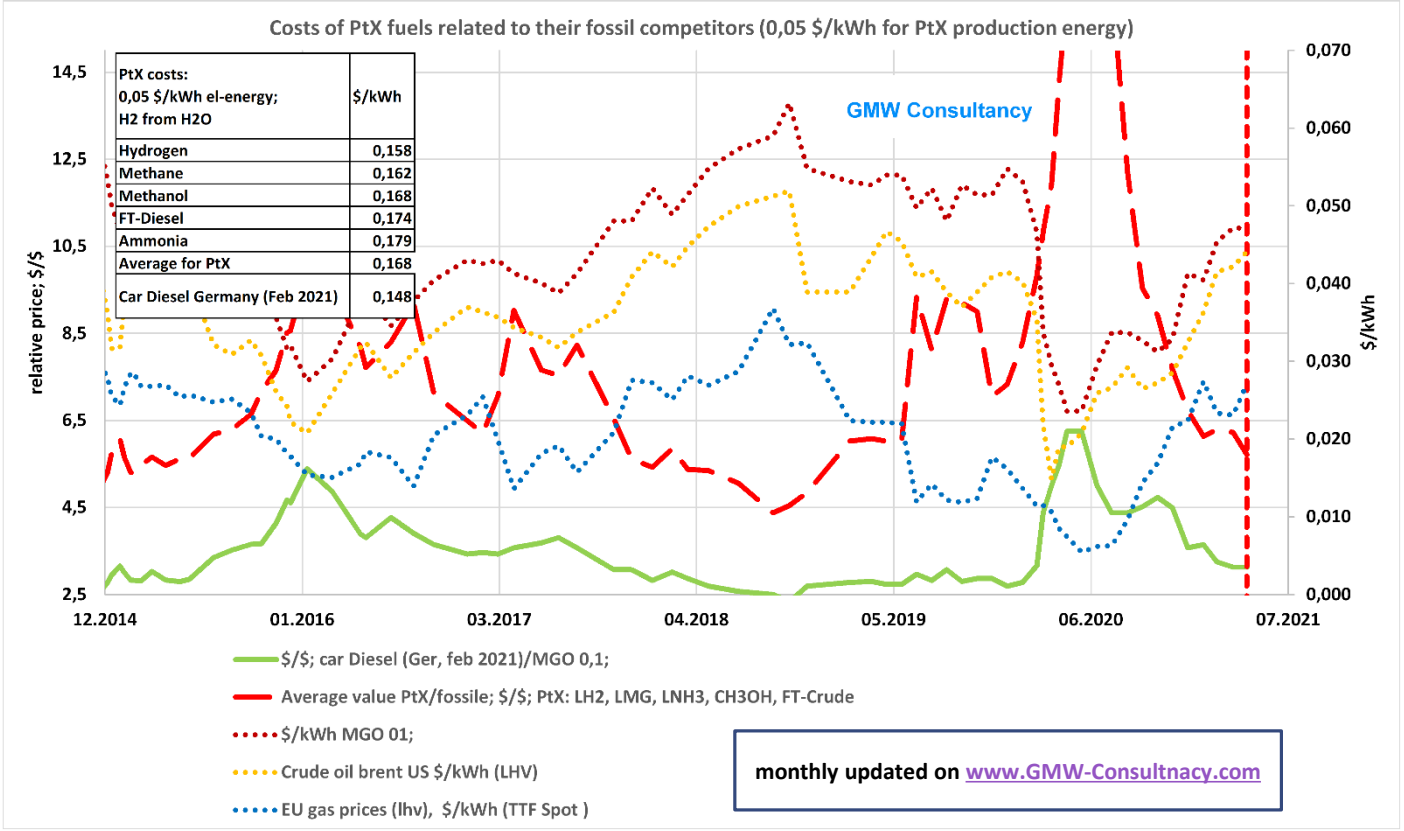
Cost level of PtX Fuel compared to fossil counterparts

- PtX fuels cost about 0,16 to 0,18 $/kWh
  - This is today about 6,5 times the cost of fossil fuels.
- For comparison: Car Diesel in Germany has a price level of about 3 times the cost of MGO



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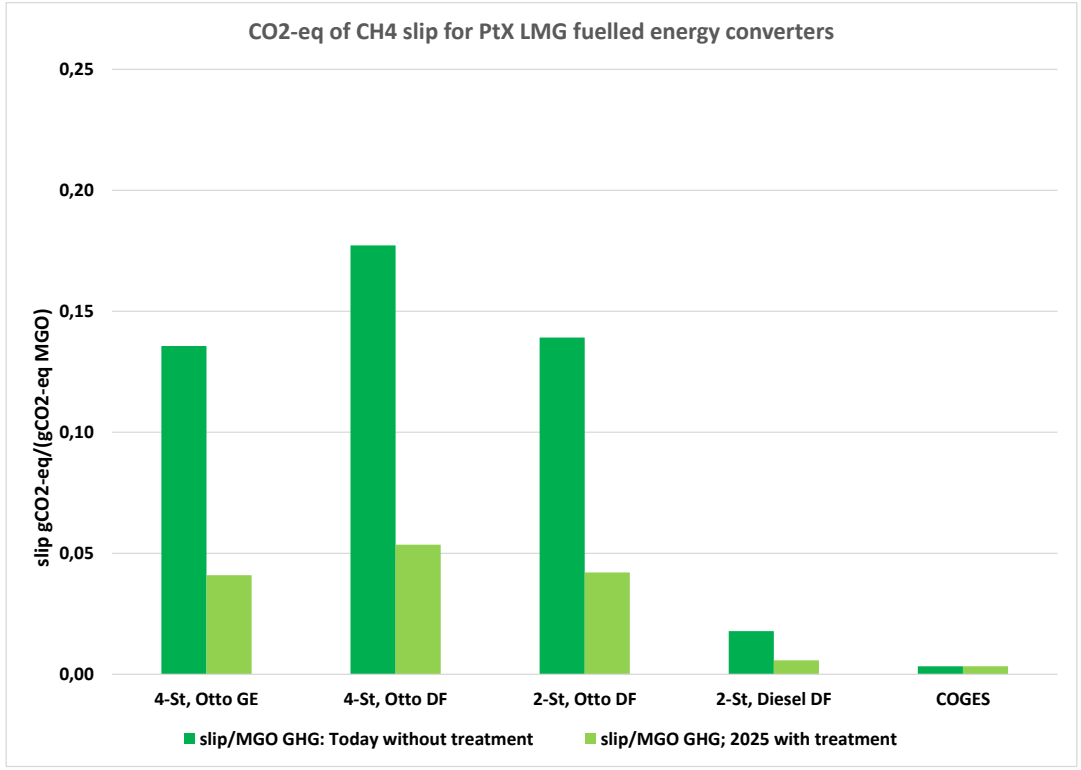
The fairytale about the bad Methane in LNG and PtX LMG (Liquefied Methane Gas)

- Using PtX Liquefied Methane Gas (LMG) instead of LNG will only have a Tank to Propeller GHG effect from Methane slip!
- The CH4 slip effect without any exhaust gas after treatment (dark green) is well below 20% of the CO2 emissions of fossil MGO fuel.
  - The benefit of fossil LNG is approx. 25% → Tank to Propeller CO2 emissions are always below CO2 emissions of fossil MGO.
- With exhaust gas after treatment slip effect is at a maximum approx. 5% of CO2 emissions of fossil MGO fuel.
- **Including Methane slip** the **reduction potential** of **PtX Methane** (LMG) is **95%** to more than **99% of CO2** emissions **from fossil MGO**.



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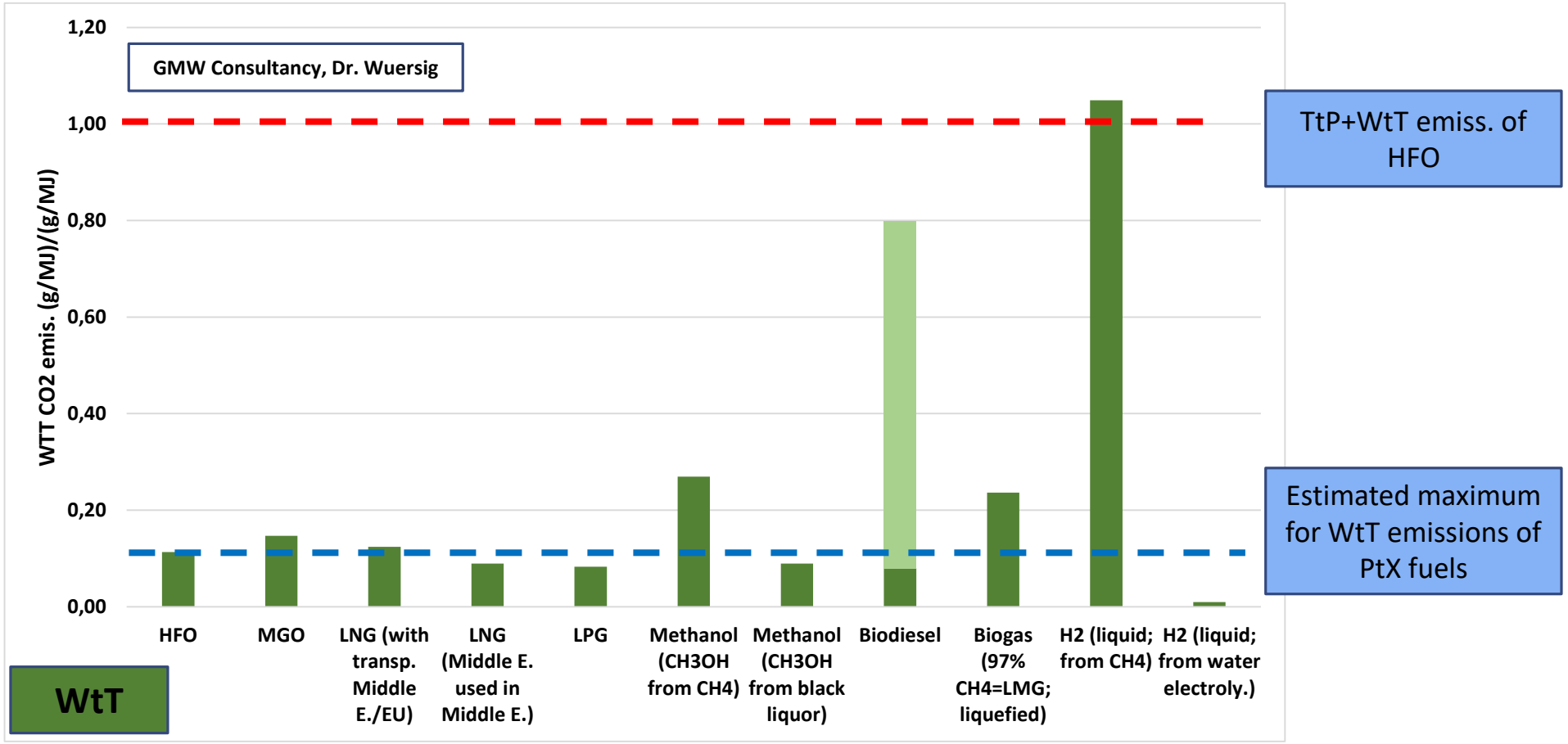
Potential for CO2 reduction
- what always remains are the emissions from production (WtT) -



Prediction toward 2050

- Fossil fuel (MGO, LNG) dominate within the next 2 decades.
- PtX fuels substitute fossil fuels as drop in fuels:
  - Liquefied Natural Gas (LNG) → Liquefied Methane Gas (LMG)
  - MGO → Bio Diesel, Fischer Tropsch Diesel (FT-Diesel)
  - Fossil Methanol (CH3OH) → PtX Methanol
- Hydrogen (H2) will play a role in niche markets (short distance close to H2 production)
- PtX Ammonia (NH3) will replaced ammonia from natural gas in the existing markets (chemical industry, fertilizer).

GMW Consultancy	2020	2021	2025	2029	2030	2040	2050
LNG (fossil)							
PtX LMG							
LPG (fossil)							
PtX CH3OH							
Bio Fuel							
PtF (FT-Diesel)							
PtX H2							
PtX NH3							
HFO, LSHFO (fossil)							
MGO (fossil)							

Relevance for shipping industry					
most relevant	highly relevant	relevant	minor relevance	not relevant	no interest
applied by a very large number of ships	applied by a large number of ships	applied by a reasonable number of ships	applied in shipping	applied by some ships	not applied

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Letztes Wort (für heute)

Die Welt mag CO2 neutral werden aber weder frei von CO2 noch frei von Kohlenstoff!

Es wird einen sehr langen Übergang mit C basierten PtX und CO2 aus CCU (Carbon Capture and Use) geben.

Danach wird der CO2 Kreislauf der PtX Brennstoffe durch CO2 aus der Abscheidung aus der Umgebungsluft geschlossen werden.

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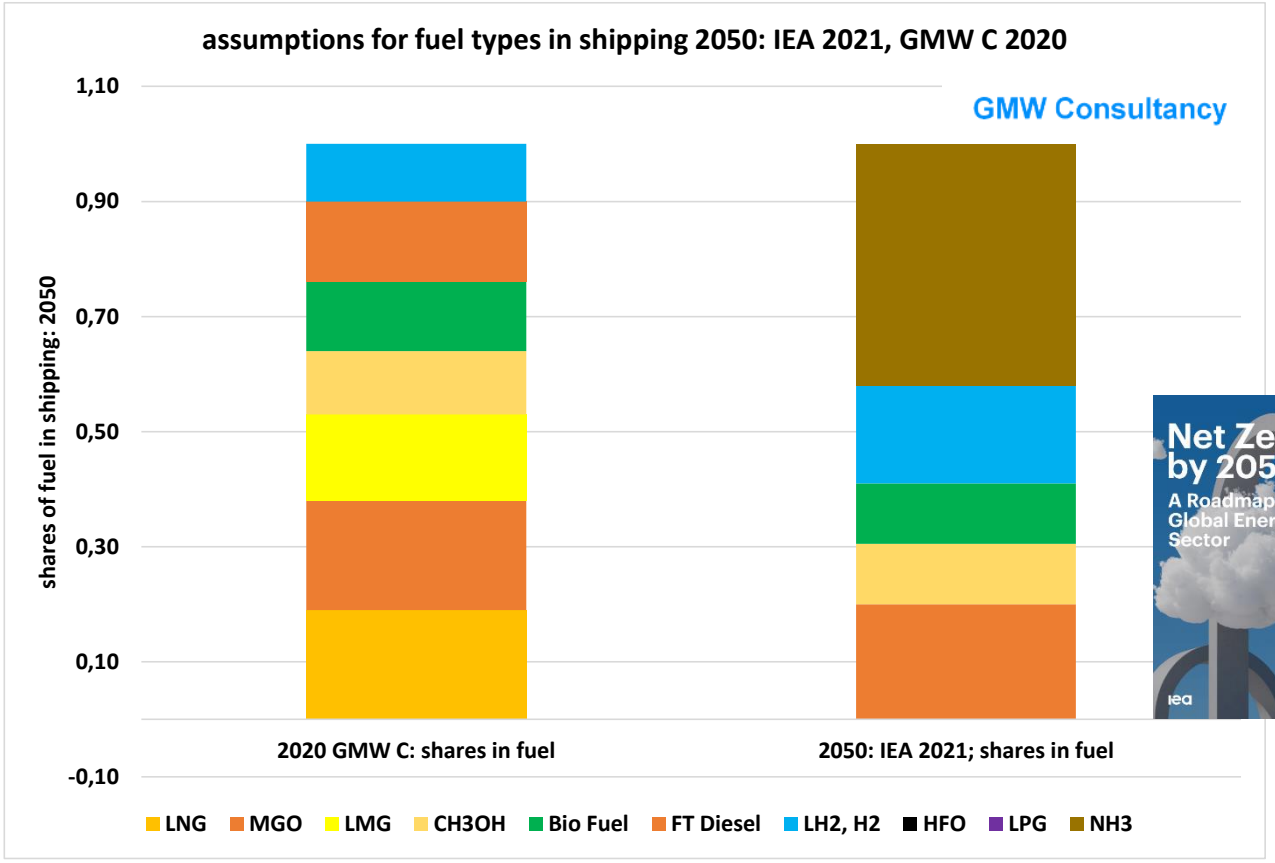
And here you find the "Bonus Material"
How may the quantitative future in ship fuel look like in 2050?

- fossil fuels:
  - LNG
  - MGO
  - HFO, LPG
- PtX fuels:
  - LMG (Liquefied Methane Gas)
  - Methanol (CH3OH)
  - Bio Fuel
  - Fischer Tropsch Diesel (FT-Diesel)
  - Liquefied Hydrogen (LH2), compressed Hydrogen (H2)
  - Liquefied Ammonia (NH3)



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