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ALTERNATIVE MARINE FUELS IN LIGHT OF CARBON EMISSION REDUCTION TARGETS – 2ND OF APRIL 2021

Dr. Elizabeth Lindstad, Chief Scientist
SINTEF Ocean AS

sfi Centre for Research-based Innovation
The Research Council of Norway

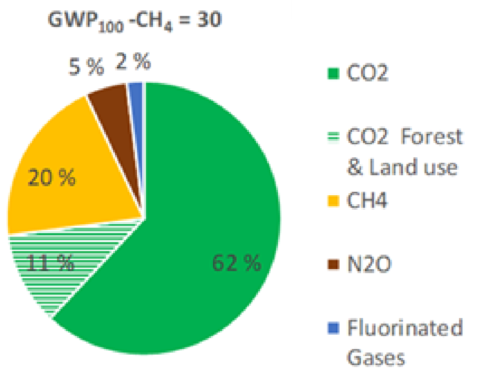
Emission regulations

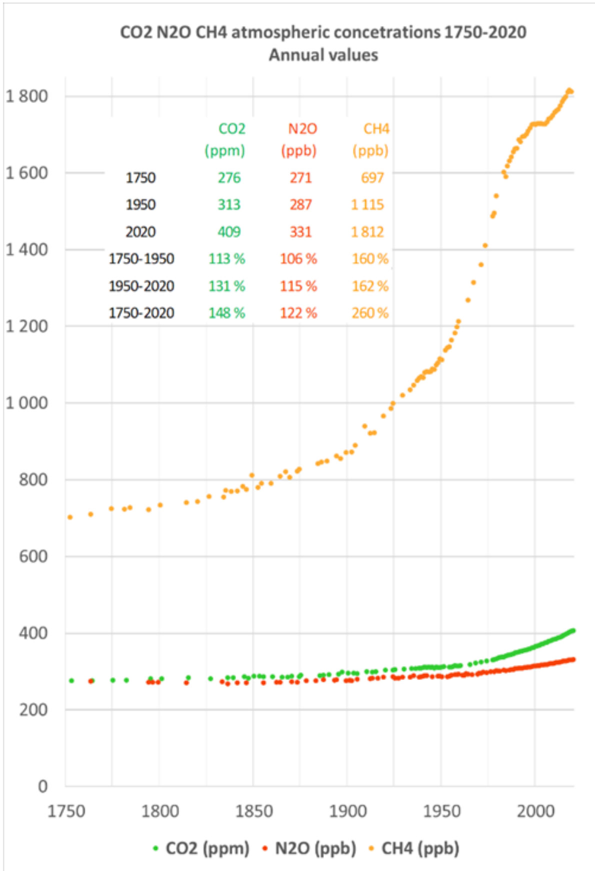
- Current regulations:
  - NO_X and SO_X regulated due to human health and local pollution
  - CO_2 regulated due to global warming through IMO's MARPOL Annex VI convention.
  - IMO regulations are on a Tank-to-Wake (TTW) basis

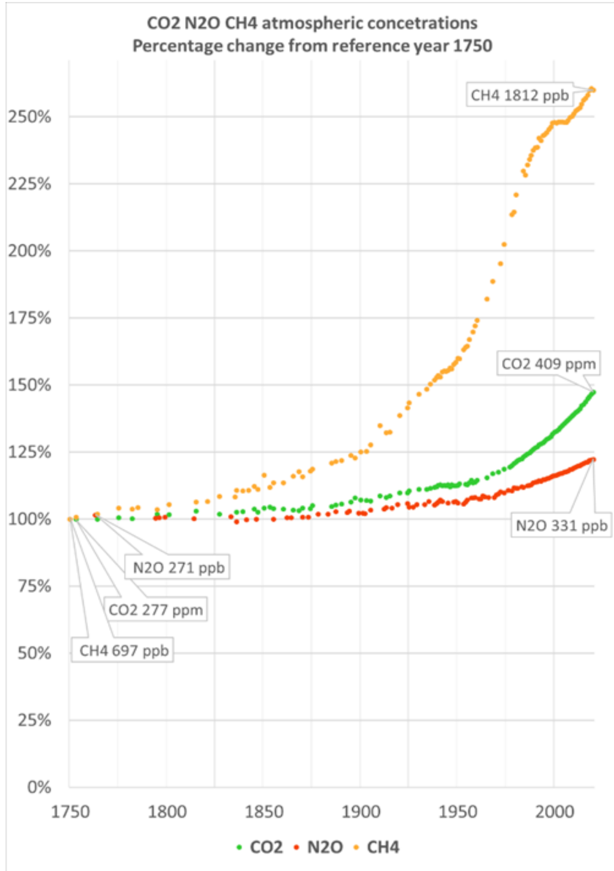
- IMO is now under increased pressure to
  - Also regulate other GHG gases, i.e. un-combusted methane (CH_4) and N_2O
  - Include the LCA of fuels on a Well-to-Wake (WTW) basis to avoid unintended consequences of the current regulations

The pressure for including all GHG's in IMO regulations is due to increased CH_4 amount in the atmosphere, and its around 20% share of annual GHG impact.

Total man-made GHG emissions in 2010, expressed in CO_2 equivalents (IPCC 2014)



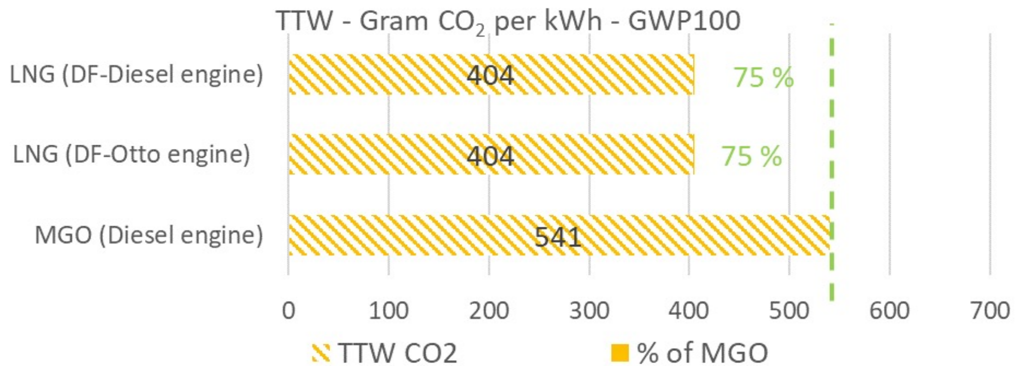


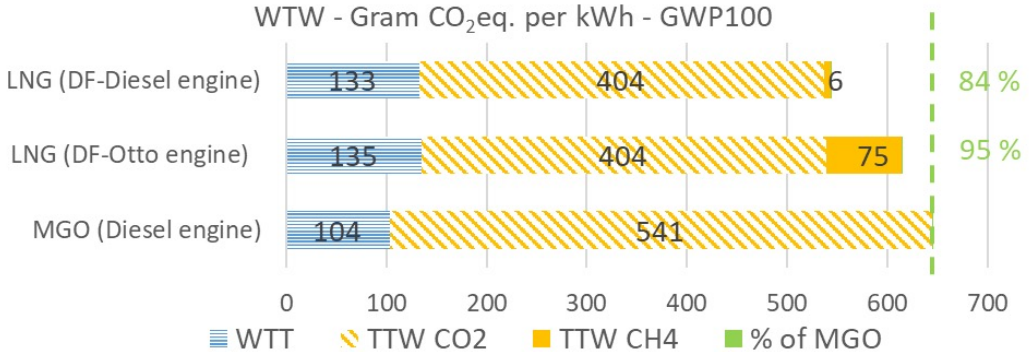


Source: Lindstad et al 2020 compiled from:
MacFarling-Meure, C., et al. (2006); CSIRO Oceans & Atmosphere and the Australian Bureau of Meteorology (2020).

GHG intensity and sustainability of all energy used onboard ships in a well-to-wake (WTW) perspective versus tank-to-wake (TTW) as is

- We compare MGO and diesel engines versus LNG and Dual Fuel Diesel engine or Dual Fuel Otto engine.
- With Tank-to-Wake "AS IS" the advantage (in the IMO systems) is 25 % compared to MGO
- With Well-to-Wake (WTW) "TO BE" the advantage of LNG DF-Diesel is reduced from 25% to 16%, and with DF-Otto its reduced from 25% to only 5%





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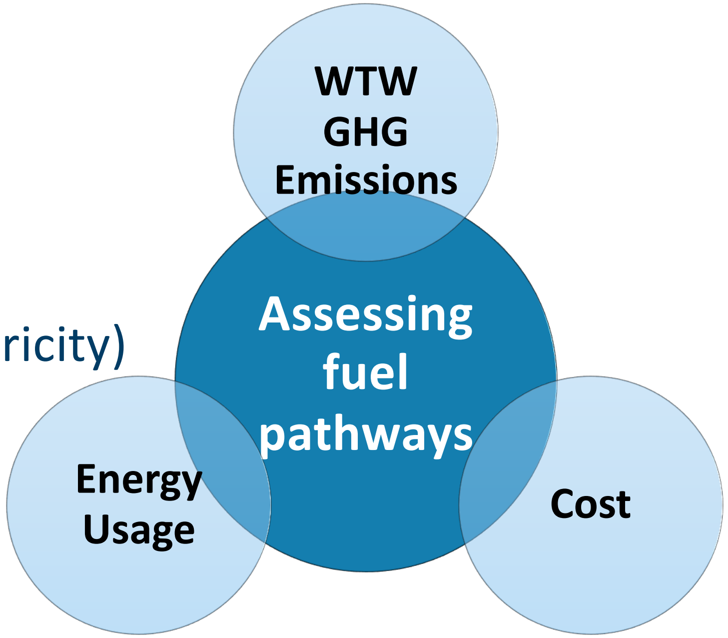
Assessing Alternative Fuel PATHWAYS with focus on GHG, Energy usage and Cost, in a Well-to-Wake perspective

- **Conventional fossil fuels**
- **Biofuels**
- **Hydrogen and ammonia** (conventional and E-fuels)
- **Synthetic E-fuels** (gaseous or liquid fuels produced from hydrogen and carbon captured by using renewable electricity)
- **Electric power** from batteries charged from the grid



Calculating Well-to-Wake GHG emissions [WTW = WTT + TTW]

	2 - stroke engines		HFO & Scrubber Diesel engine	VLSFO Diesel engine	MGO Diesel engine	LNG DF Diesel engine	LNG DF Otto engine	MGO DF Diesel engine	MGO DF Otto engine
[1]	CO_2 emission factors	g CO2 / g fuel	3.114	3.176	3.206	2.75	2.75	3.206	3.206
[1]	Low Calorific Value	MJ/kg	40.2	41.0	42.7	49.2	49.2	42.7	42.7
[1]	CH_4 - GWP100	CO2 e				30	30		
[1]	CH_4 - GWP20	CO2 e				85	85		
[2]	Thermal engine efficiency	%	50 %	50 %	50 %	50 %	49.2 %	50 %	47 %
[3]	Compared to Diesel engine	%				100 %	98 %	100 %	94 %
[3]	SFOC - Main fuel	Gram/kWh	179.1	175.6	168.6	145.3	147.6	168.6	179.4
[2]	SFOC - Pilot Fuel	Gram/kWh				1.5	1.5		
[2]	Methane Slip	Gram/kWh				0.25	2.5		
[3]	TTW - GWP100 CO_2 eq.	Gram/kWh	558	558	541	412	486	541	577
[3]	TTW - GWP20 CO_2 eq.	Gram/kWh	558	558	541	426	623	541	577
[2]	WTT - GWP100 CO_2 eq.	Gram/MJ	9.6	13.2	14.4	18.5	18.5	14.4	14.4
[3]	WTT - GWP100 CO_2 eq.	Gram/kWh	69	95	104	133	135	104	110
[2]	WTT - GWP20 CO_2 eq.	Gram/MJ	14.1	19.6	20.8	27.9	27.9	20.8	20.8
[3]	WTT - GWP20 CO_2 eq.	Gram/kWh	102	141	150	201	204	150	160
[3]	WTW - GWP100 CO_2eq.	Gram/kWh	627	653	644	545	621	644	687
[3]	WTW - GWP20 CO_2eq.	Gram/kWh	659	699	690	626	827	690	737
[3]	WTW - GWP100 in % of MGO		97 %	101 %	100 %	85 %	96 %	100 %	107 %
[3]	WTW - GWP20 in % of MGO		95 %	101 %	100 %	91 %	120 %	100 %	107 %

Example from 2-stroke engine:

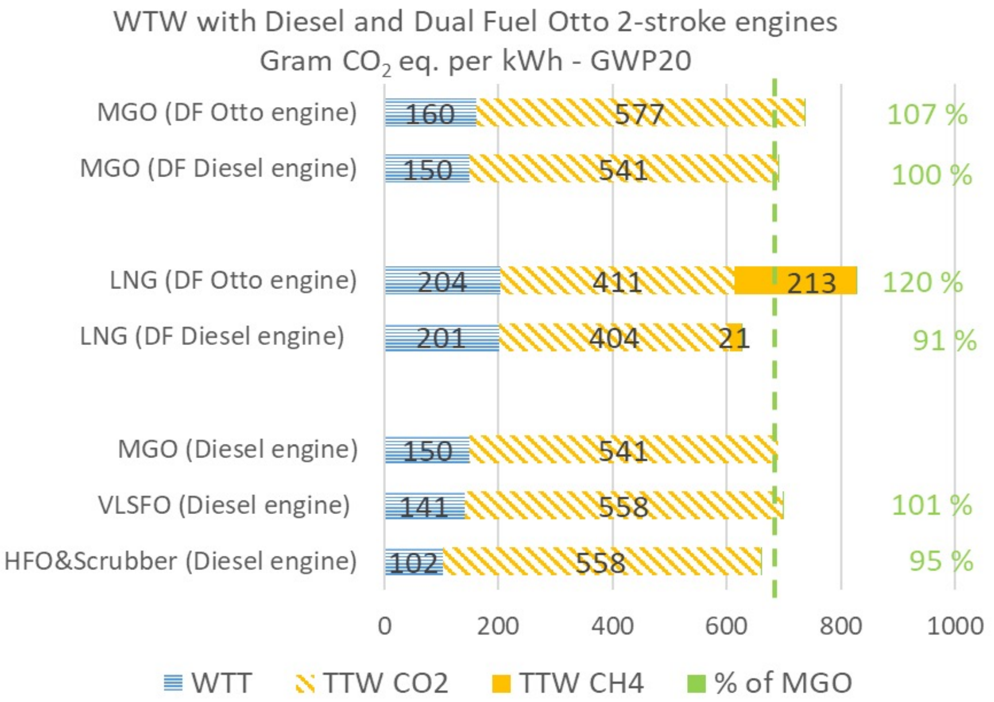
[1] Fuel specifics and GWP values for methane are consensus values

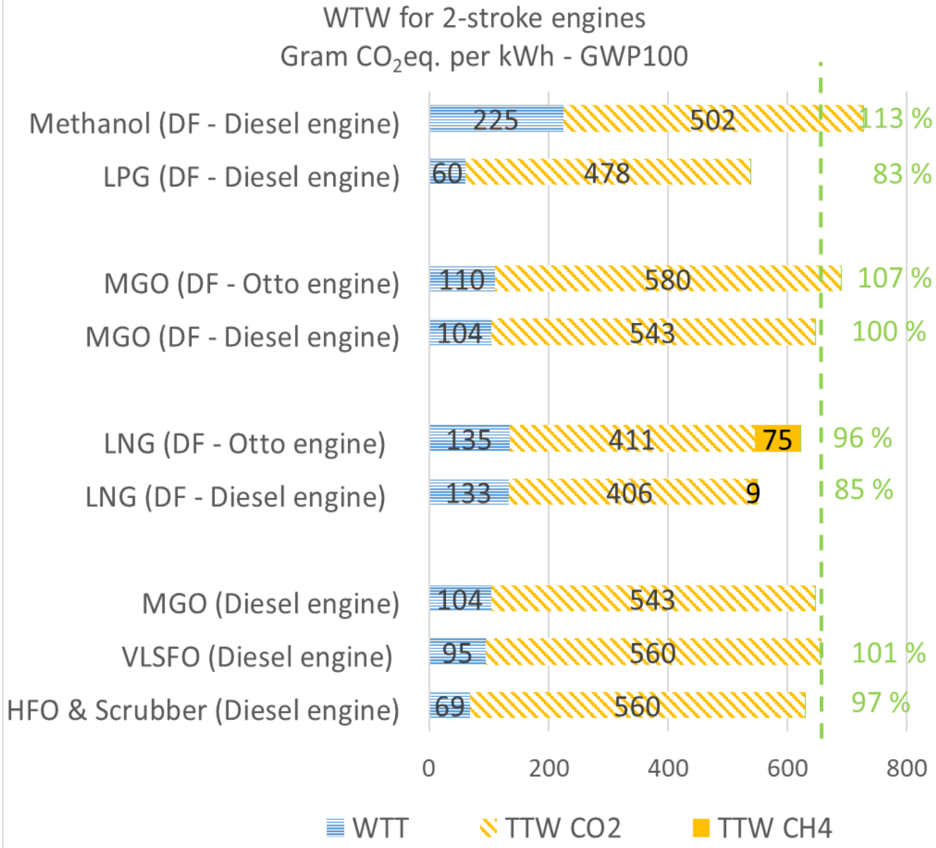
[2] References values:

- Thermal efficiency of 50% (2-stroke engines) minus the methane slip for all engines based on Lindstad et al. (2020)
- Well-to-Tank values for HFO & Scrubber based on Concawe (2012, 2018), Lindstad (2019), CE-Delft (2020)
- Well-to-Tank values for VLSFO, MGO and LNG reflect a consensus Thinkstep (2019), ICCT (2020); Lindstad and Rialland (2020)

[3] Calculated values

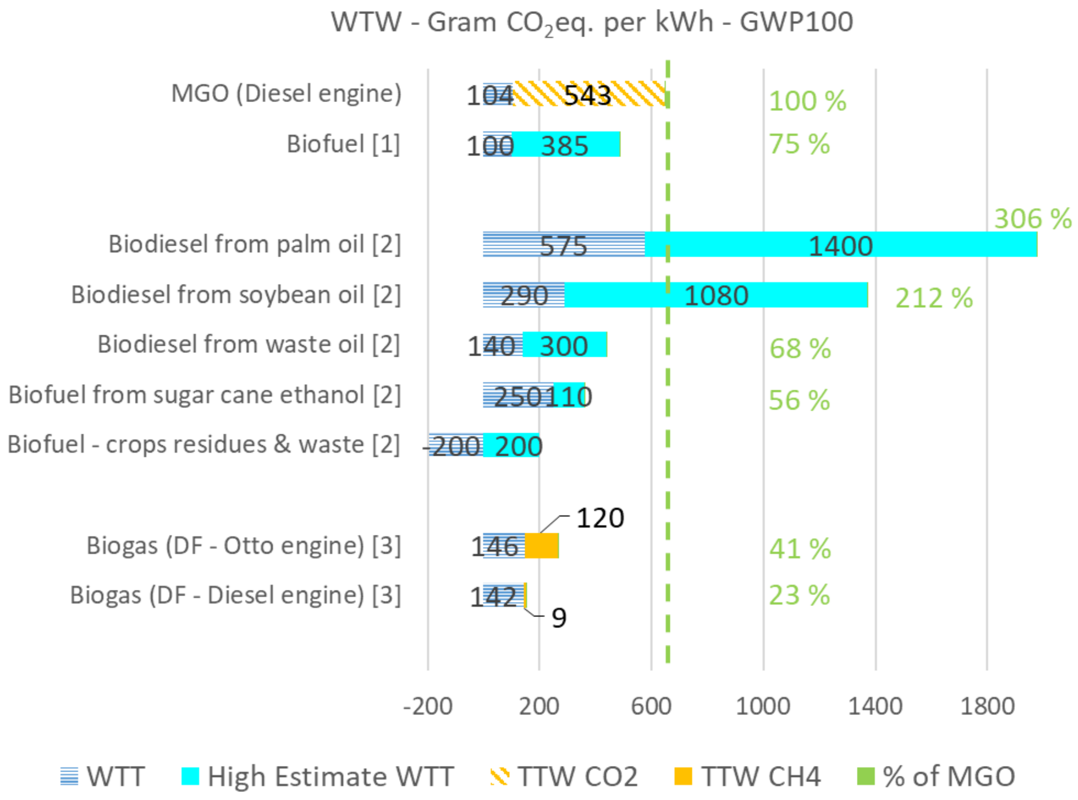
Conventional Fuels: comparing GWP20 and GWP100, i.e. short term (20 years) versus long term (100 years) impact





Note that: Methanol and LPG only included in GWP 100 figure.

Bio-fuels



Source [1] is the *State-of-the-Art technologies, measures, and potential for reducing GHG emissions from shipping* study (Bouman et al., 2017).

Source [2] is *The Role of Sustainable Biofuels in Decarbonising Shipping* (SSI, 2019) presented at Cop 25 in December 2019.

Sources for [3] are: Thinkstep (2019), for the basic Biogas WTT; and Lindstad (2019), for the impact of un-combusted methane, which is the same level as for fossil fuels (see LNG figures, previous slide)

MEPC 75 submissions arguing for including all GHGs and WTW emissions for all fuels

- ISWG 7/3 – FOEI, WWF, Greenpeace, Pacific Environment, Clean Shipping Coalition: Propose to include all GHG emissions including methane into EEDI.
- ISWG-GHG 7/3/1 – SGMF (The Society for Gas as a fuel): To further reduce GHG, they suggest to add methane by means of a CO_2 eq. in relevant IMO measures and guidelines, including EEDI.
- ISWG-GHG 7/5/1 – EUROMOT: To achieve the IMO GHG reduction targets, a significant improvement of lifecycle GHG intensity of marine fuels is required.
- ISWG-GHG 7/5/5 – CESA (European shipyards associations): LCA of all alternative fuels are needed and the current EEDI is not capable of handling the increased portfolio of alternative fuels.
- ISWG-GHG 7/5/6 – IMarEST (membership org. as RINA and SNAME): Pressing need for IMO take a whole life cycle approach of alternative fuels to avoid unintended consequences (increased GHG emissions).
- ISWG-GHG 7/5/9 – EU member states and EU Commission: The need for development of LCA guidelines to estimate WTW emissions of alternative fuels.

Methodology to calculate the life cycle, well-to-wake (WTW) Greenhouse gas (GHG) emissions of fuels used onboard ships

- These guidelines propose a methodology to calculate the life cycle, well-to-wake (WTW) GHG emissions of both conventional fuels and any other alternative energy sources used to power ships.
- **They are a result of a 15 months long process**; Involving EC, Member states, Environmental NGO's, Engine and Technology Provides, Oil & Shipping companies, Research (SINTEF Ocean, MARIN)
- **The next foreseen steps are:**

- EC to introduce the LCA submission ISWG GHG 7/5/9 during the IMO informal meeting on LCA in mid-April;
- EC and MS to support discussion on LCA during ISWG-GHG 8 and MEPC76;
- **EC with the support of ESSF and MS** to prepare a [Union] submission on the LCA for MEPC77 (late 2021)

Methodology to calculate the life cycle, well-to-wake (WTW) Greenhouse gas (GHG) emissions of fuels used onboard ships

- IMO regulatory tools are and will be based on the IMO Data Collection System (DCS). Under DCS every ship's total GHG emissions is calculated as per the following formula:

$$Total\ fuel\ consume\ (t) * \ CF_{TTW}(\frac{t\ CO2}{t\ fuel})$$

- Where, CF = Fuel mass to CO_2 mass convertor at the Tank-to-Wake (TTW) level.

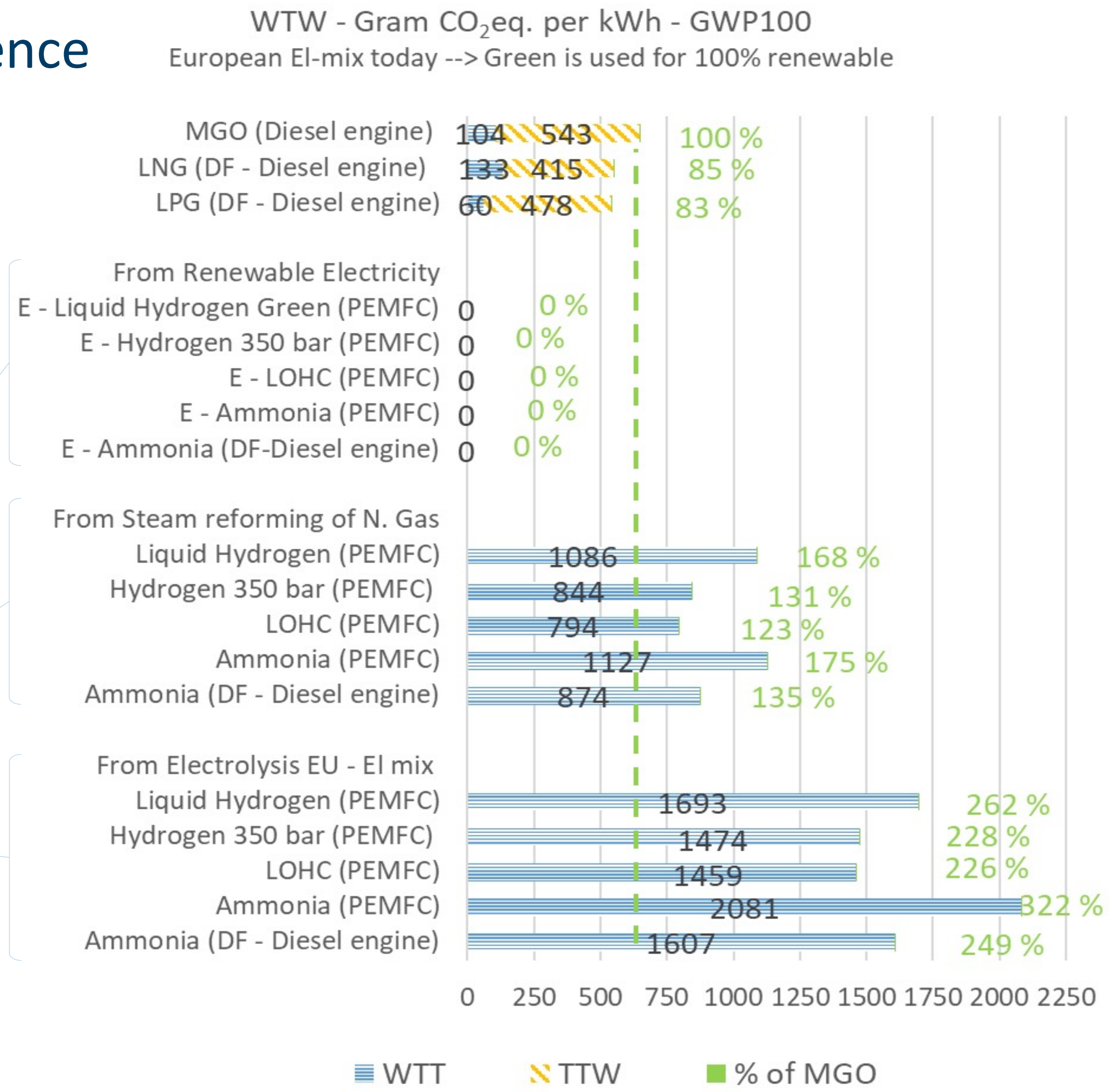
- The following simple formulas offer a new ***life-cycle carbon-equivalent factors*** (LCCF) covering the to **replace the conventional TTW carbon factors (CF)** that have been used in existing regulatory instruments. **This simple approach enables the operators and the regulators to keep on using the existing fuel consumption data:**

$$Total\ WtW\ Emissions(t\ CO2eq) = \sum_{i}^{n-engine} \sum_{j}^{m-fuel} (M_{ij} * LCCF\_WtW\_fuel_{ij}) + \sum_{i}^{n} (E_i * LCCF\_electricity_i)$$

The LCCF will make a large difference for Hydrogen and Ammonia

With today's CF factors based on TTW the source and its production pattern do not count, the value is just Zero despite that it is only the E-type which has Zero emissions:

- From electrolysis with renewable energy
- From steam reforming of natural gas
- From electrolysis with EU-el-mix



From Gram CO_2eq. per kWh and MJ to CO_2eq. per 1 kg Fuel

- MGO: (14.4 + 75.1) Gram CO_2 eq./MJ * 3.6 MJ/kWh / 50% thermal efficiency = (104 + 541) Gram CO_2 eq./kWh * 1000gram /168.6 gram/kWh = 3 825 Gram CO_2
  MGO a *carbon-equivalent factors* (LCCF) = 3.8 The old CF = 3.2
- LNG DF (Otto): WTT + TTW + Methane Slip (133 + 404 + 2.5*30) Gram CO2 eq./kWh * 1000gram /145.2 gram/kWh = 4 214 Gram CO2
  LNG&DF-Otto engine a *carbon-equivalent factors* (LCCF) = 4.2 The old CF = 2.75
- Liquid Hydrogen: WTT + TTW (151 + 0) Gram CO_2 eq./MJ * 3.6 MJ/kWh / 50% = (1088) Gram CO_2 eq./kWh * 1000gram /60 gram/kWh = 18 133 Gram CO_2
  H2 from Natural Gas a *carbon-equivalent factors* (LCCF) = 18.1 The old CF = 0

Life-cycle carbon factor (LCCF) for fuel use by mass (tonne CO2eq/tonne fuel) – columns in grey font colour are only for informative purposes.									
Fuel and engine types	*WTT (g CO2e/MJ - 100 yrs) (inc. LUC)*	**LCCF_WTT (t CO2eq/t fuel)***	TTW (t CO2/t fuel)	TTW engine slip (t CO2eq/t fuel)**	**LCCF_TTW (t CO2eq/t fuel)****	**LCCF_WtW (t CO2eq/t fuel)*****	VLSFO equivalent (mass basis)	Engine slip factors (%)**	Energy density by LHV (MJ/kg)
HFO	9.6	**0,41**	3.11	0	**3,11**	**3,5**	3,4		40,2
MGO	14,4	**0,61**	3,2	0	**3,2**	**3,8**	3,7		42,7
VLSFO	13,2	**0,54**	3,17	0	**3,17**	**3,7**	3,7		41
LNG (DF high-pressure 2 stroke)	18,5	**0,91**	2,75	0,06	**2,81**	**3,7**	3,1	0,2%	49,2
LNG (DF low-pressure 2 stroke)	18,5	**0,91**	2,75	0,61	**3,36**	**4,2**	3,5	1,7%	49,2
LNG (DF low-pressure 4 stroke)	18,5	**0,91**	2,75	1,13	**3,88**	**4,7**	3,9	3,1%	49,2
H2 (natural gas)	151,0	**18,12**	0	0	**0**	**18,1**	6,2		120
H2 (renewable electrolysis)	0,0	**0,00**	0	0	**0**	**0,0**	0		120
NH3 (natural gas)	121,0	**2,25**	0	0	**0**	**2,3**	5		18,6
NH3 (renewable electrolysis)	0,0	**0,00**	0	0	**0**	**0,0**	0		18,6
Methanol (natural gas)	31,3	**0,62**	1,38	0	**1,38**	**2,0**	4,1		19,9
Methanol (renewable electrolysis + DAC)	0,0	**0,00**	0	0	**0**	**0,0**	0		19,9
E-diesel (with RES & DAC)	0,0	**0,00**	0	0	**0**	**0,0**	0		42,7
Biodiesel (Rapeseed) (incl. LUC)	115,1	**4,28**	0	0	**0**	**4,3**	4,7		37,2
Biodiesel (Palm) (incl. LUC)	306,7	**11,41**	0	0	**0**	**11,4**	12,6		37,2
BioLNG (Organic waste) (DF high-pressure 2 stroke)	13,8	**0,68**	0	0,06	**0,06**	**0,7**	0,6	0,2%	49,2
BioLNG (Organic waste) (DF low-pressure 2 stroke)	13,8	**0,68**	0	0,61	**0,61**	**1,3**	1,1	1,7%	49,2
BioLNG (Organic waste) (DF low-pressure 4 stroke)	13,8	**0,68**	0	1,13	**1,13**	**1,8**	1,5	3,1%	49,2

* Biodiesel includes LUC in this example

** CH_4 slip for LNG and biomethane, as a fraction of fuel consumption for different engines, based on the data from IMO 4th GHG study.

*** Only CO_2 emissions and methane slip are included for this example; N_2O emissions from NH_3 combustion is not well-understood for now, but the methodology is flexible and can be later added once more data becomes available.

INTERNATIONAL MARITIME ORGANIZATION

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INTERSESSIONAL MEETING OF THE WORKING GROUP ON REDUCTION OF GHG EMISSIONS FROM SHIPS
7th session
Agenda item 2

ISWG-GHG 7/2/26
18 September 2020
ENGLISH ONLY

FURTHER CONSIDERATION OF CONCRETE PROPOSALS TO IMPROVE THE OPERATIONAL ENERGY EFFICIENCY OF EXISTING SHIPS, WITH A VIEW TO DEVELOPING DRAFT AMENDMENTS TO CHAPTER 4 OF MARPOL ANNEX VI AND ASSOCIATED GUIDELINES, AS APPROPRIATE

Proposal for a mandatory goal-based technical and operational short-term measure with combination of EEXI, SEEMP, CII and rating mechanism

Submitted by China, Croatia, Denmark, France, Germany, Ghana, India, Italy, Japan, Nigeria, Norway, Singapore, Spain, United Arab Emirates and ICS

SUMMARY	
Executive summary:	This document contains a proposal to combine the measures submitted by documents ISWG-GHG 7/2/6, ISWG-GHG 7/2/9, ISWG-GHG 7/2/14 and ISWG-GHG 7/2/21
Strategic direction, if applicable:	3
Output:	3.2
Action to be taken:	Paragraph 32
Related documents:	ISWG-GHG 7/2/6, ISWG-GHG 7/2/7, ISWG-GHG 7/2/9, ISWG-GHG 7/2/14 and ISWG-GHG 7/2/21

Introduction

1 The Marine Environment Protection Committee, at its seventy-fourth session (13 to 17 May 2019), instructed the Working Group on Reduction of GHG Emissions from Ships at its sixth and seventh intersessional meeting (ISWG-GHG 6 and ISWG-GHG 7) to further consider concrete proposals to improve the operational energy efficiency of existing ships, to develop draft amendments to Chapter 4 of MARPOL Annex VI and associated Guidelines, as appropriate. This document is submitted in accordance with paragraph 9 of Circular Letter No.4181/Rev.1 on the Resumption of the seventh session of the Intersessional Working Group on Reduction of GHG Emissions from Ships (ISWG-GHG 7).

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SUSTAINABLE SHIPPING FOR A SUSTAINABLE PLANET

SHORT TERM MEASURES AGREED ON INTERSESSIONAL 19-23 OCTOBER TO BE CONFORMED BY MEPC IN NOVEMBER

Proposal for a mandatory goal-based technical and operational short-term measure with combination of EEXI, SEEMP, CII and rating mechanism

CO-SPONSORED BY:

China, Croatia, Denmark, France, Germany, Ghana, India, Italy, Japan, Malaysia, Nigeria, Norway, Republic of Korea, Singapore, Spain, United Arab Emirates, ICS

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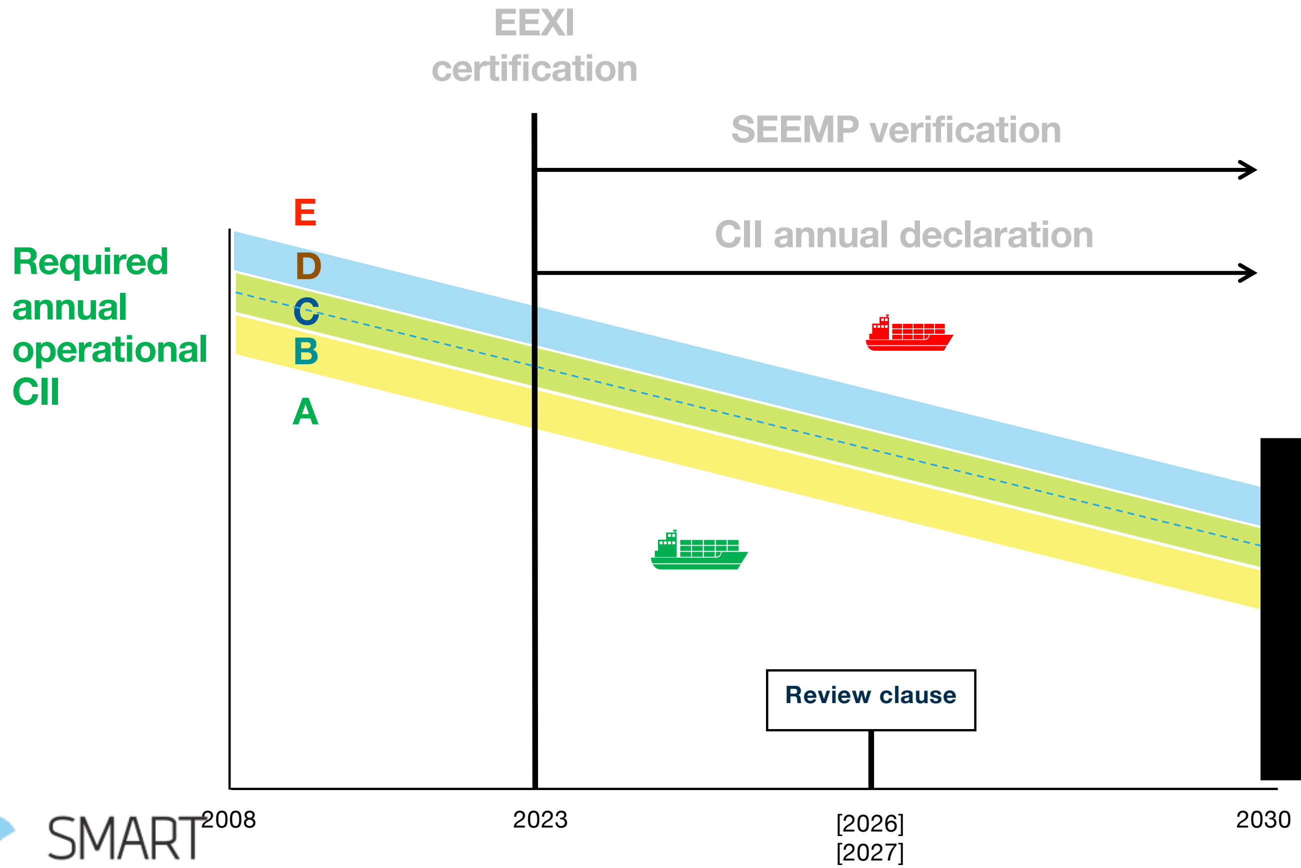
Part A: Agreement part



- The pathway is represented linearly for ease of presentation.
- CII = Carbon indicator

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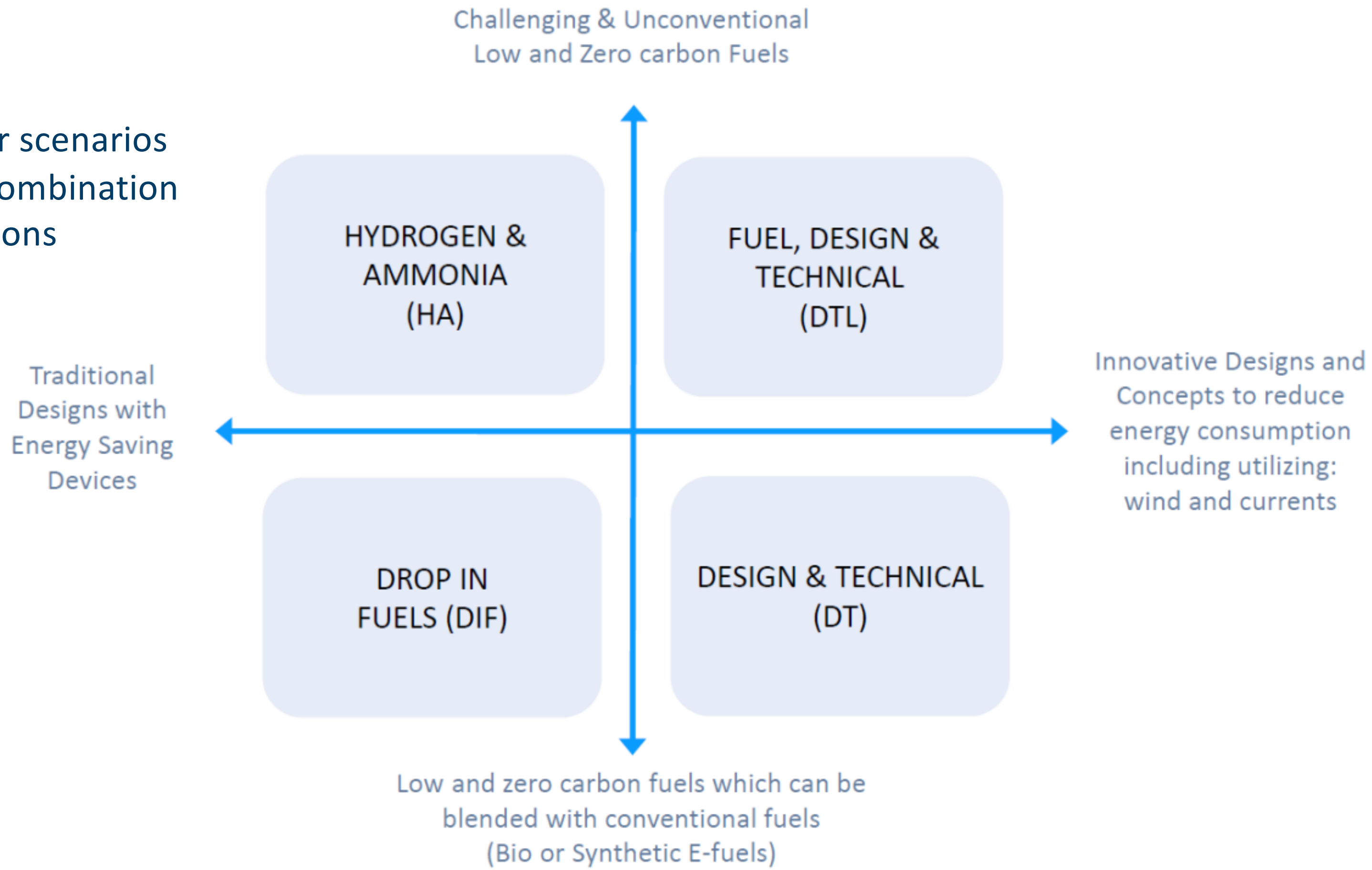
A ship's GHG emissions and Cii rating is a function of its (1) design, (2) fuel carbon content and (3) operation.

Drivers of a ship's GHG emissions and Cii rating:

1. Decisions taken at the **design** and building stage
2. The **GHG content of its fuel** at any time compared to using 100% MGO or VLSFO (for example 50% if MGO and E-diesel are blended)
3. The ship's **operation** (scheduling, operational speed, operational area, maintenance)

Four scenarios of combination options



Synthetic E-fuels

- Synthetic electro-fuels or E-fuels are gaseous or liquid fuels from hydrogen and captured carbon using renewable electricity
- They have high energy efficiency and are compatible with and blends easily: for example MGO & E-diesel or LNG & E-LNG
- No need for new infrastructure or bunkering facilities in contrast to Hydrogen and Ammonia
- Can be used on existing vessels
- No need for additional crew training

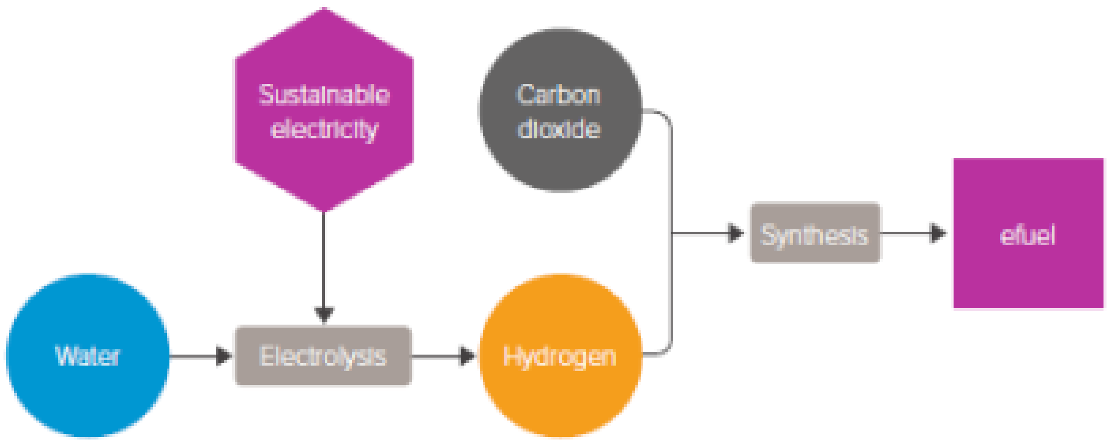
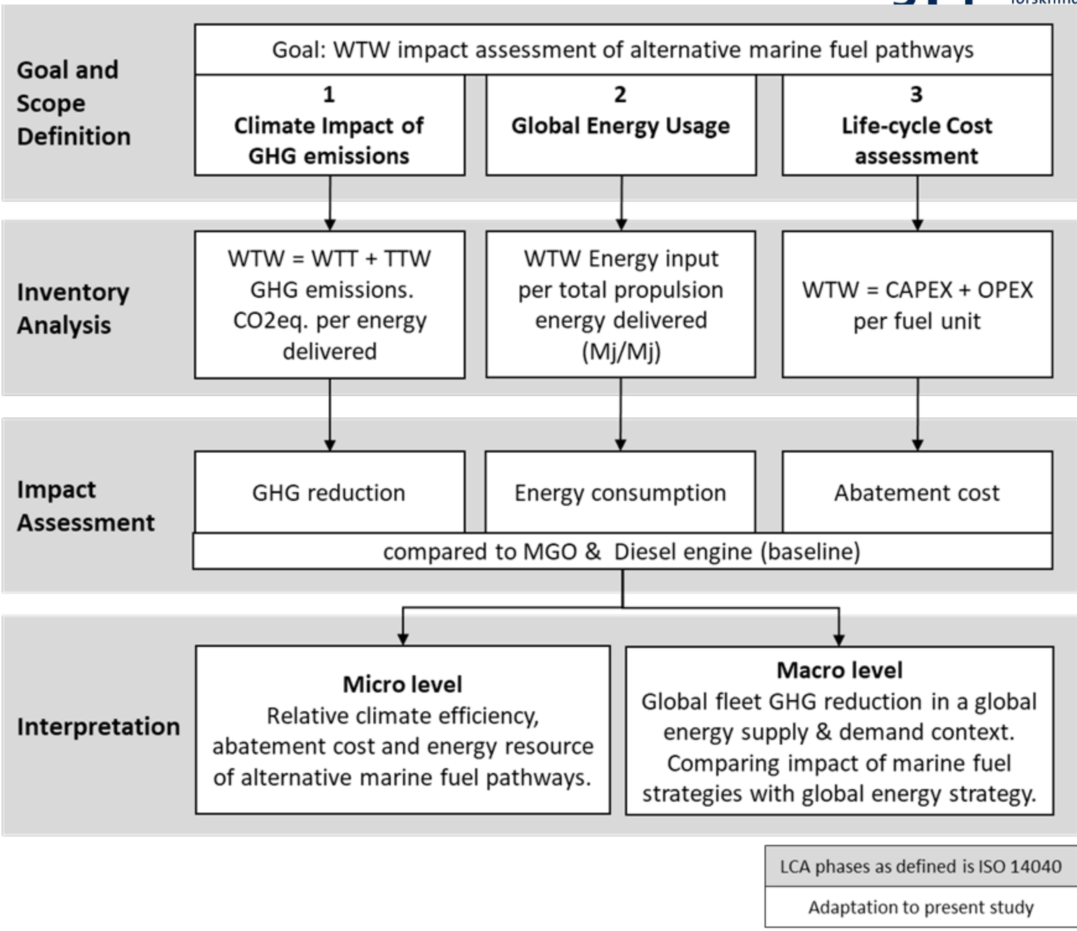


Figure Source: The Royal Society (2019)

To evaluate the alternative options we compare their:

- GHG reduction
- Energy consumption
- Abatement Cost

Which enables a holistic assessment and that the solutions which are best to reach global objectives are selected



Source : Lindstad, E., Gamlem, G., Rialland, A., Valland, A, - Assessment of Alternative Fuels and Engine technologies to reduce GHG, SMC-099-2021

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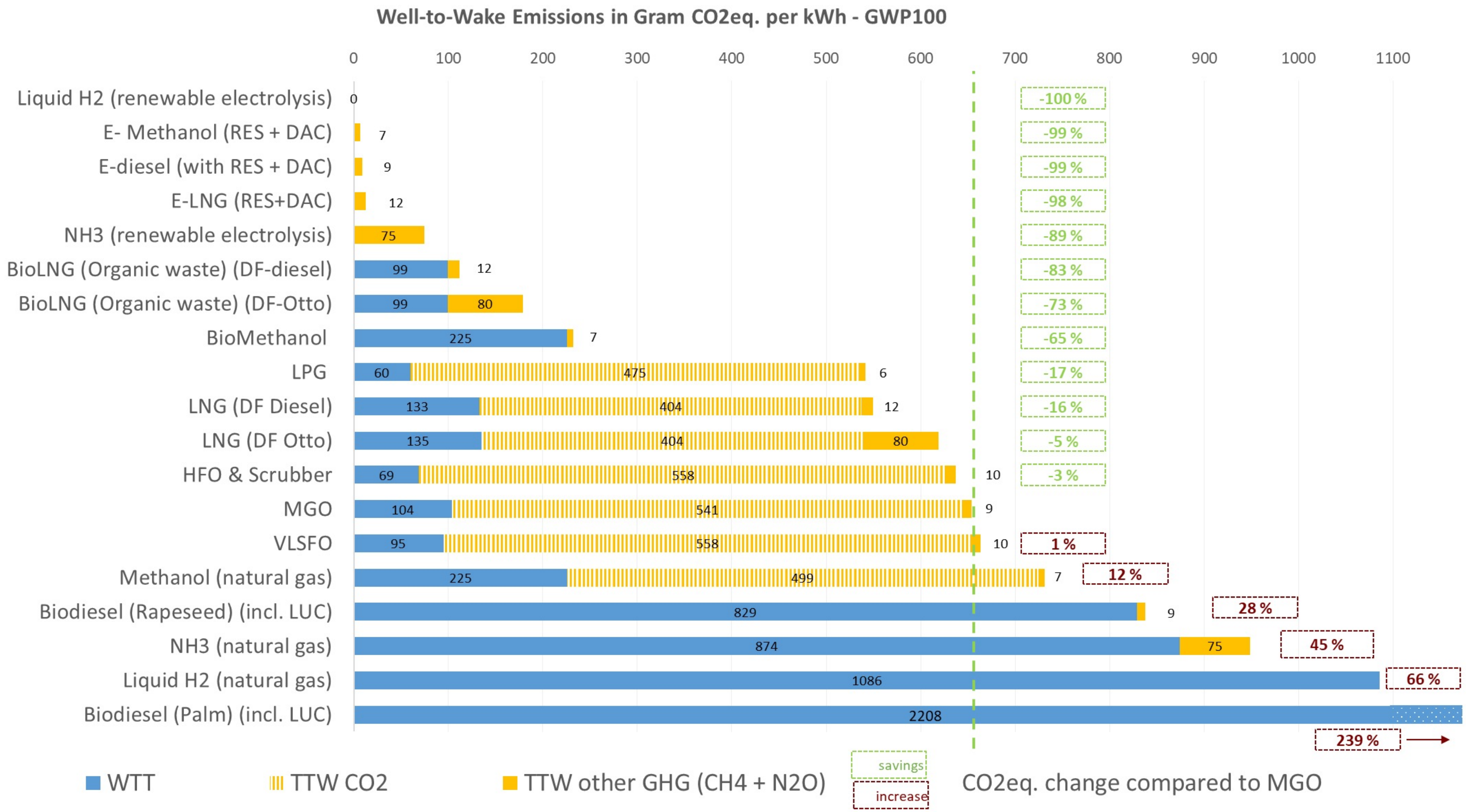
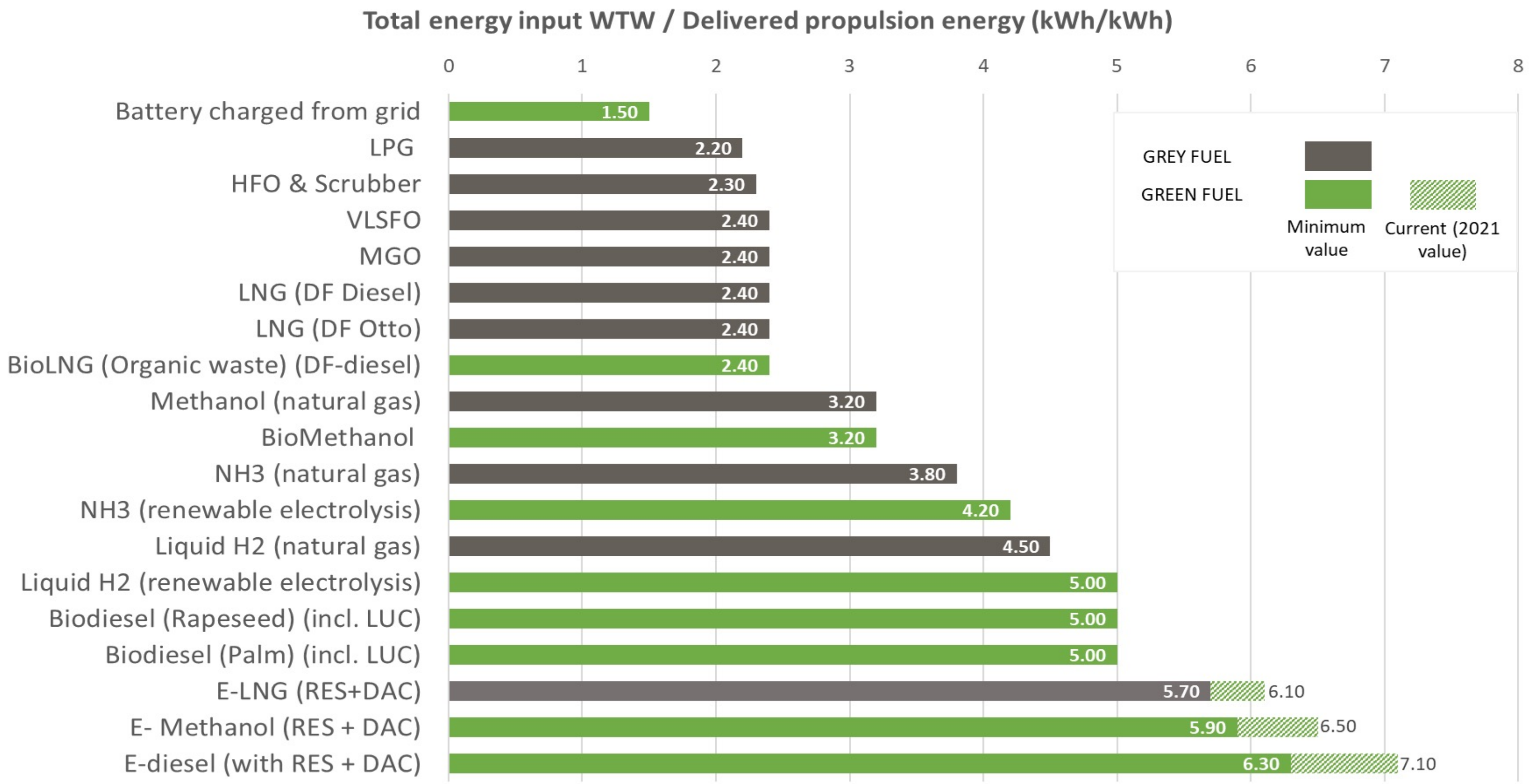
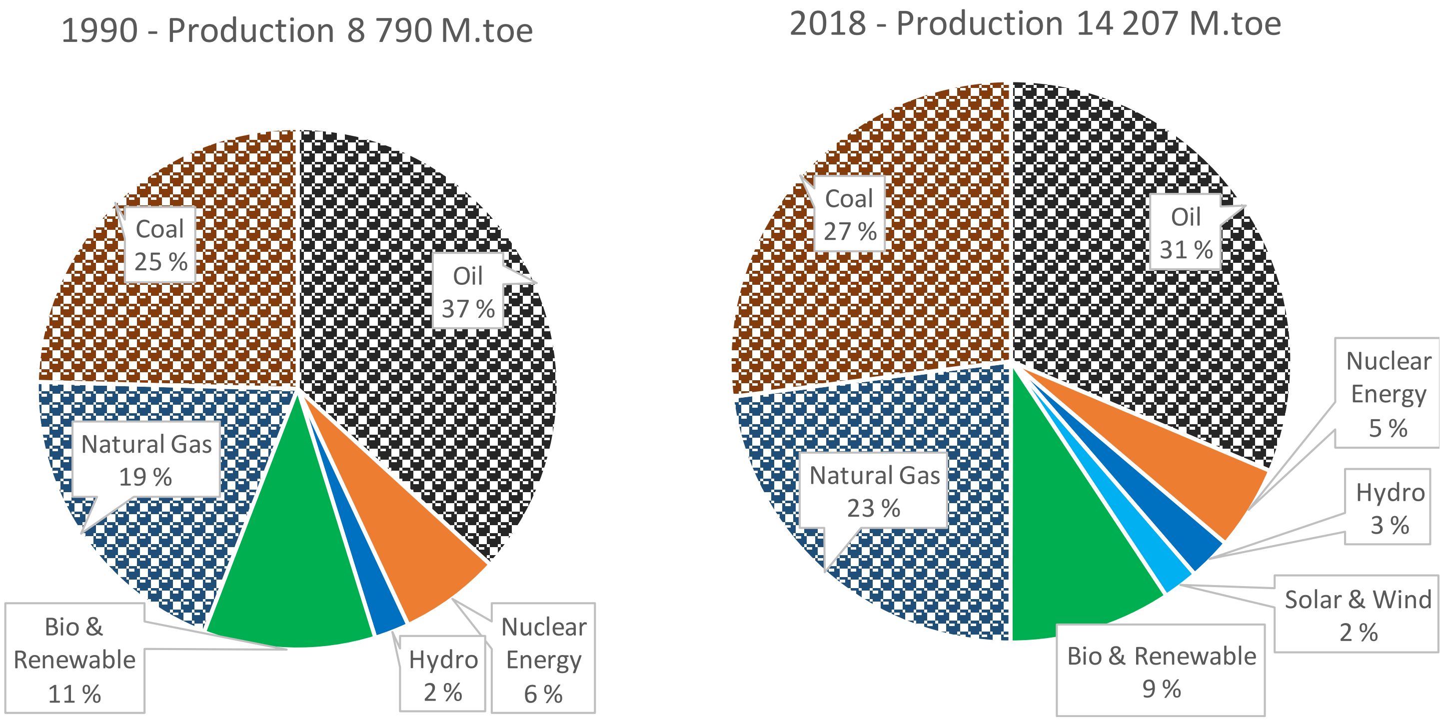
Assessment of Fuels based on GHG reduction potential



Assessment of Fuels based on energy used WTW per kWh delivered for propulsion

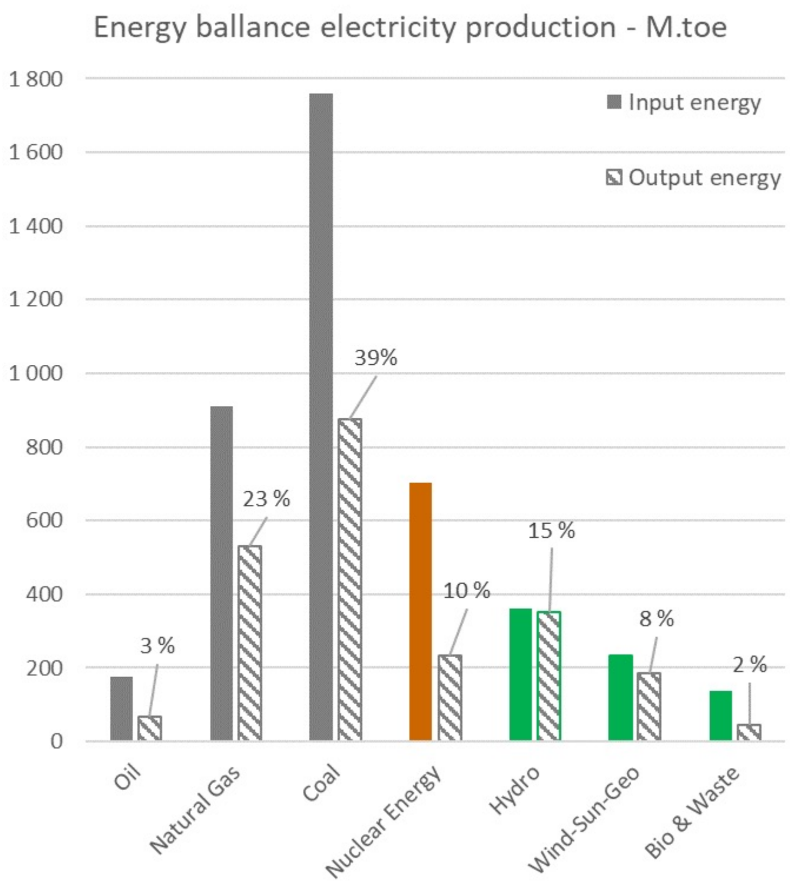


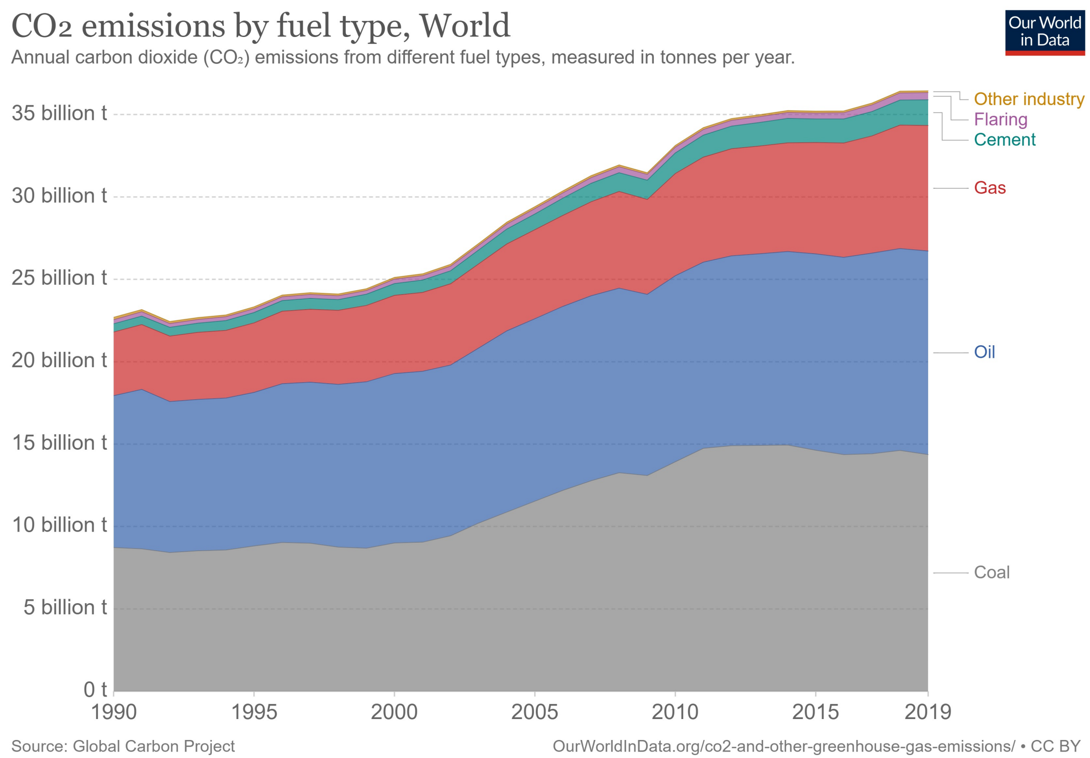
E-fuels require large amount of Renewable Electricity – will these quantities become available?



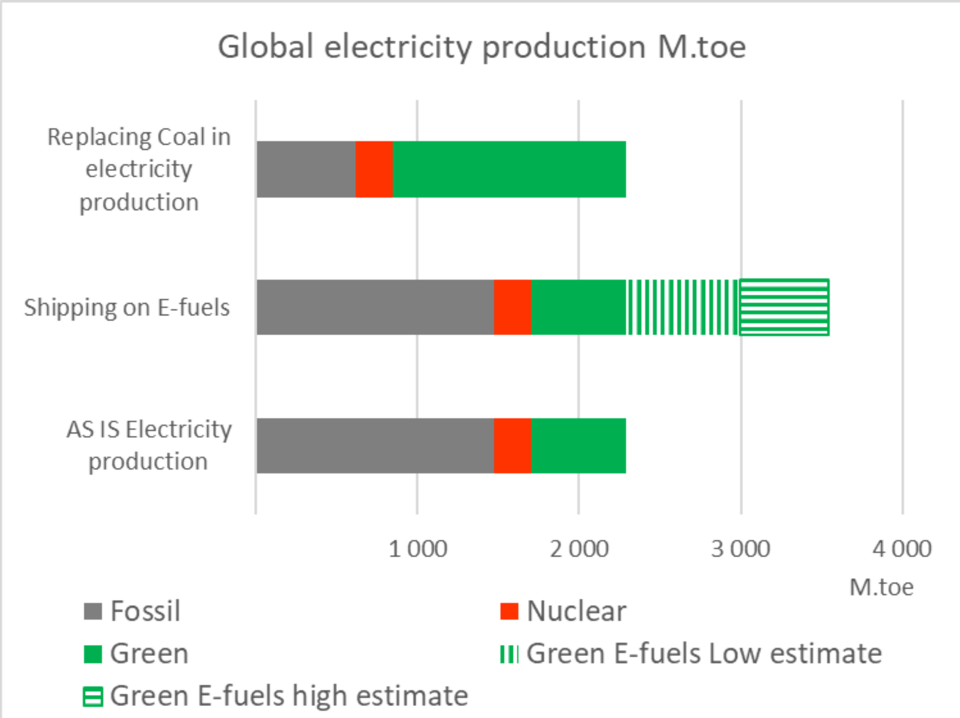
Datasource: IEA.org

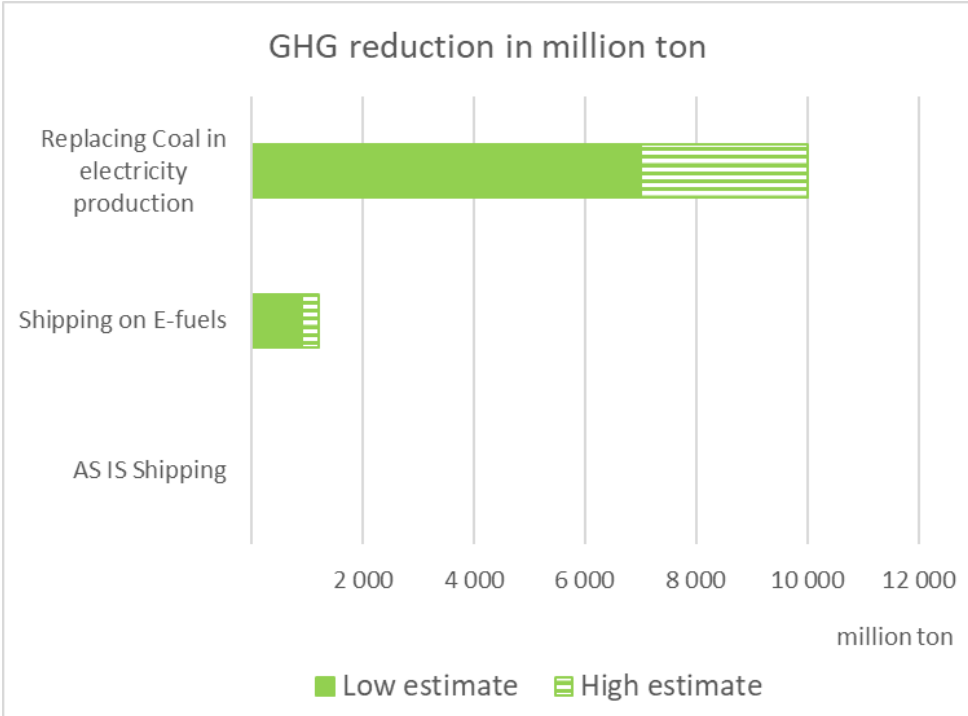
Coal accounts for 40 % of man-made CO_2 emissions, of which 2/3 are used in power plants to produce electricity (65% of electricity is fossil)





Why use renewable electricity to produce E-fuels for shipping, when global GHG emissions can be reduced 5 – 10 more times per kWh by instead replacing coal fired power plants





Fuel costs projections

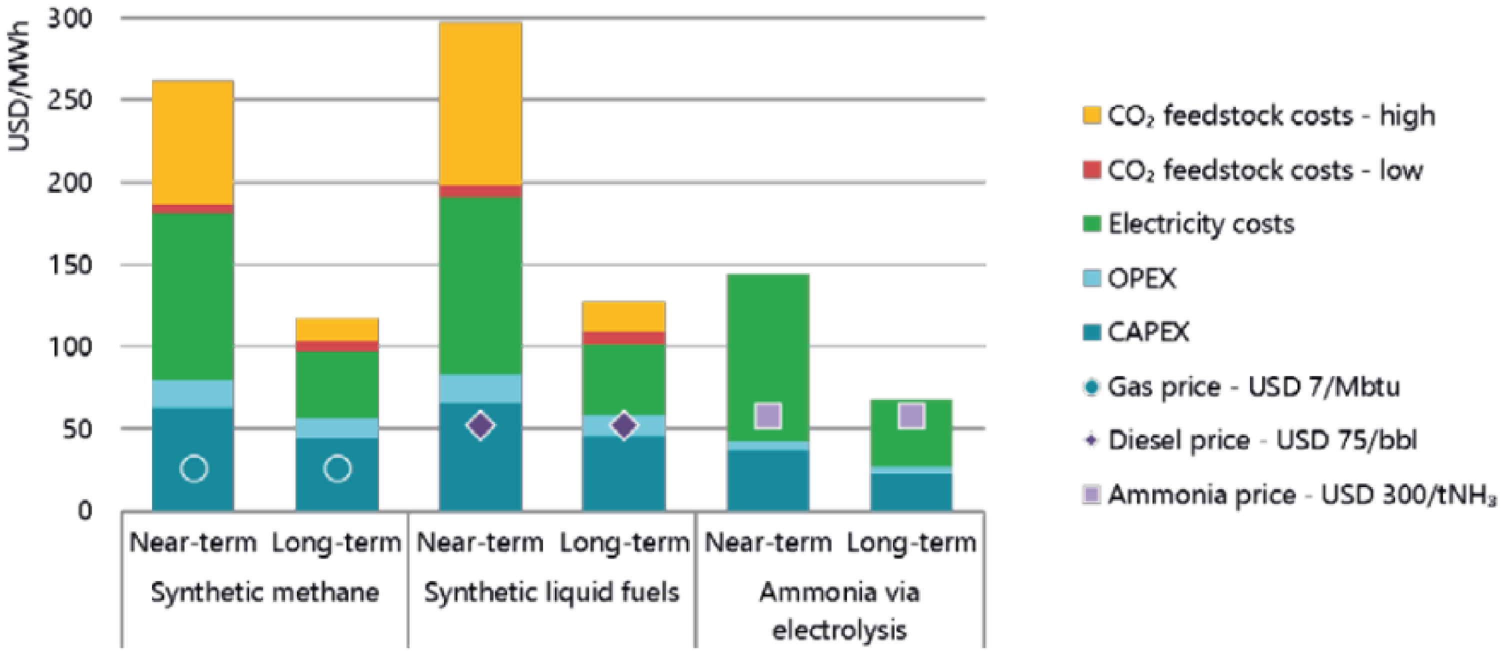
Fuel Price Projections 2020-2050 - Lower bound (USD/Gj) from Lloyd's Register and UMAS (2020) 1 – 4 - 10

Primary energy source	Fuel	2020	2030	2040	2050
Oil	LSHFO	8	11	11	11
Biomass	Bio-Diesel	22	24	27	29
Biomass	Bio-methanol wood	23	25	27	30
Biomass	Bio-methanol waste stream	19	21	23	25
Substitution price from biofuels		9	19	26	33
Renewable electricity	E-diesel	130	114	99	83
Renewable electricity	E-methanol	84	73	63	52
Renewable electricity	E-LNG	69	60	51	42
Renewable electricity	E-ammonia	55	47	39	30
Renewable electricity	E-hydrogen	52	44	36	28
Natural gas	NG-ammonia	28	26	24	23
Natural gas	NG-hydrogen	25	23	21	19

Reference: Techno-Economic Assessment of Zero-Carbon Fuels (Lloyd's Register and UMAS, March 2020).

Price estimates IEA 2019 Hydrogen report

Figure 22. Indicative production costs of electricity-based pathways in the near and long term



Notes: NH_3 = ammonia.; renewable electricity price = USD 50/MWh at 3 000 full load hours in near term and USD 25/MWh in long term; CO_2 feedstock costs lower range based on CO_2 from bioethanol production at USD 30/tCO_2 in the near and long term; CO_2 feedstock costs upper range based on DAC = USD 400/tCO_2 in the near term and USD 100/tCO_2 in the long term; discount rate = 8%. More information on the underlying assumptions is available at www.iea.org/hydrogen2019.

Source: IEA 2019.

E-fuels and synthethic E-fuel calculations (Lindstad et al 2021)

	Present	Future	
Annual operating hours with NG	5000	5000	hours
Annual operating hours with electricity	5000	5000	hours
Cost per kWh of NG	0.025	0.025	USD/kWh
Cost per kWh of Electricity	0.060	0.020	USD/kWh
Capex and Opex DAC (Direct carbon capture from air)	0.20	0.10	USD per kg of CO2
Operational energy needed for DAC	2.60	1.50	kWh/kg of CO2

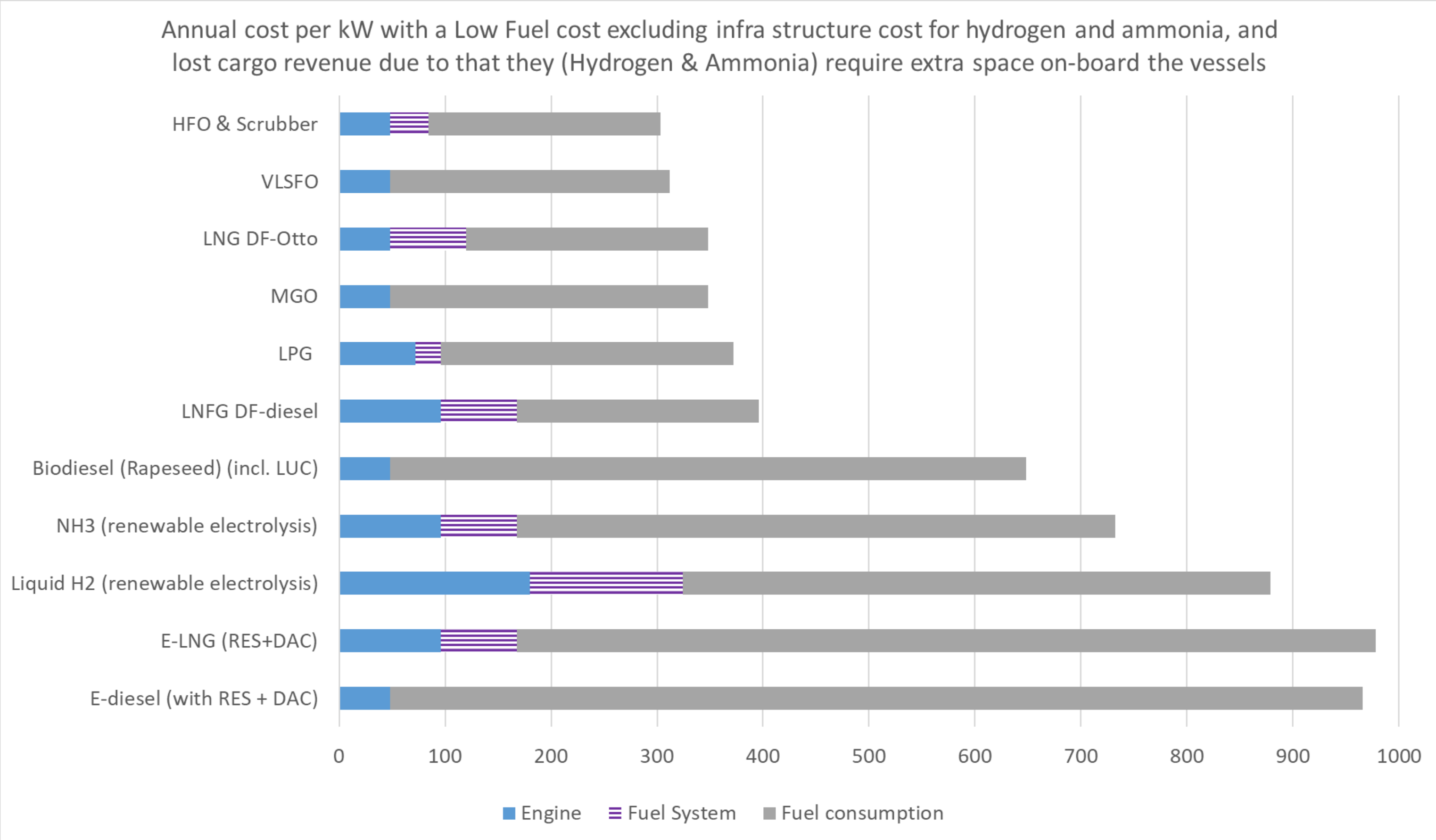
		Input	Output	WTW Input/ Output - MJ/MJ	Annual Capex + Opex	Annual cost of Energy	Total annual cost	Cost per MWh	Present cost USD per GJ	Future Cost USD/GJ
	MGO	510	per ton	500	per toe			43	12.0	12.0
	VLSFO	430	per ton	440	per toe			38	10.5	10.5
	LNG	445	per ton	380	per toe			32	9.0	9.0
	NG	345	per ton	295	per toe			25	7.0	7.0
Hydrogen	NG	100 %	76 %	3.2	134	166	300	60	16.7	16.7
	Electricity	100 %	69 %	3.5	103	435	538	108	29.9	13.8
Liquid Hydrogen	NG	76 %	53 %	4.5	45	428	473	95	26.3	26.3
	Electricity	69 %	48 %	5.0	42	768	810	162	45.0	22.0
Ammonia	NG	76 %	63 %	3.8	113	361	474	95	26.4	26.4
	Electricity	69 %	57 %	4.2	102	648	750	150	41.6	22.2
E-LNG	Electricity	69 %	46 %	5.2	103	803	906	181		
	DAC		7 %		242	136	378	76		
		69 %	40 %	6.1		939	1284	257	71.3	32.0
E-Diesel	Electricity	69 %	43 %		106	862	969	194		
	DAC		9 %		327	230	556	111		
		69 %	34 %	7.1		1092	1525	305	84.7	36.3
E-Methanol	Electricity	69 %	46 %	5.2	68	810	878	176		
	DAC		9 %		316	191	507	101		
		69 %	37 %	6.5		1001	1385	277	76.9	32.2

Comparing the values found in the quoted studies

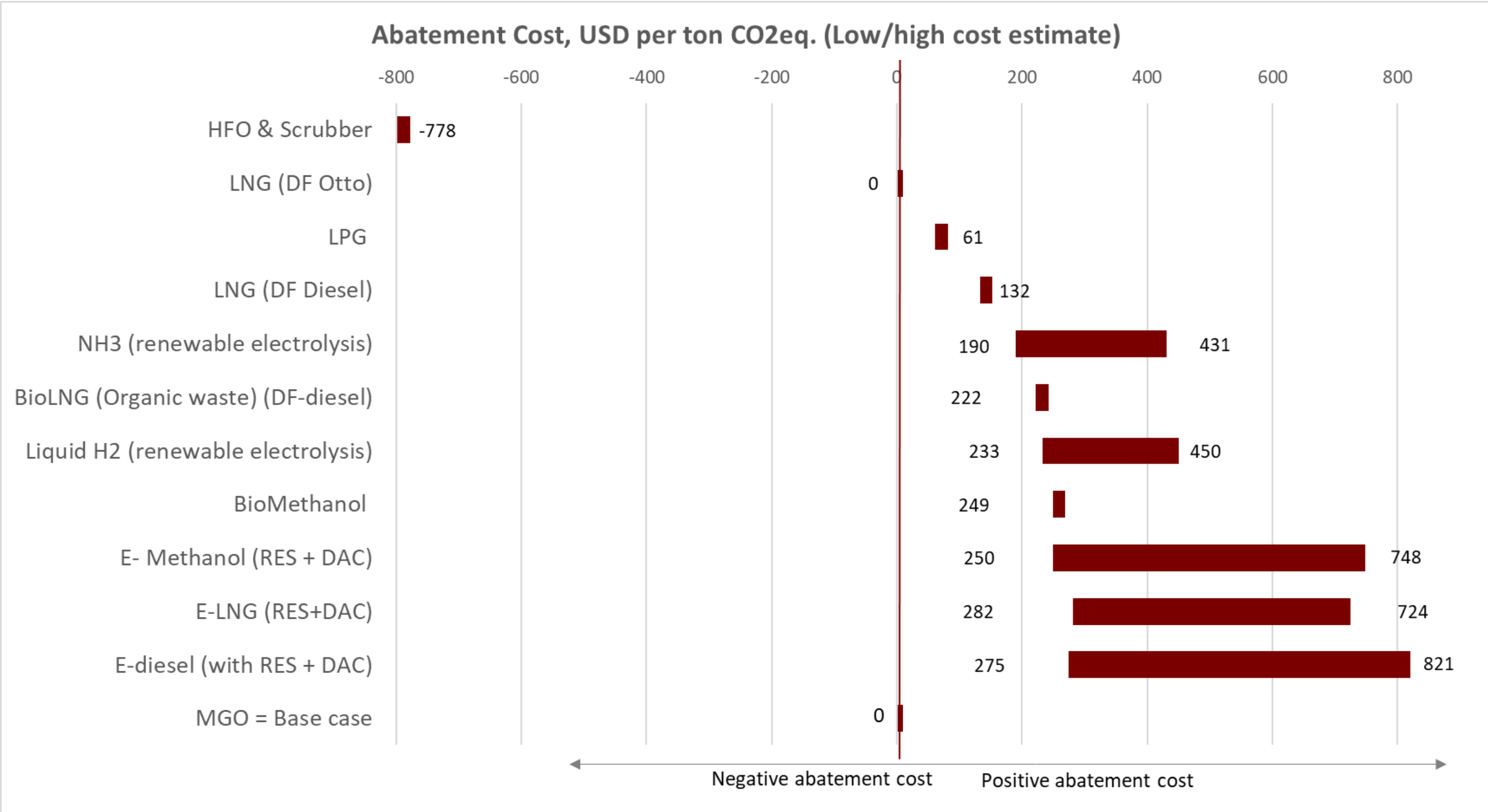
- LR & UMAS ratios compared to VLSFO are (1-3-4-8)
- IEA and Lindstad ratios compared to VLSFO are (1-2-3-3)
- World Bank (2021) study are based on LR & UMAS and favour ammonia
- If Lindstad are correct, Synthetic E-fuels are competitive when all costs are included

	All cost USD per GJ	LR & UMAS 2020	IEA - Hydrogen 2019	This study -Lindstad et al 2021	Ratio compared to VLSFO (Lindstad et al. 2021)
AS IS	VLSFO	8		11	
	E-Ammonia	55	39	42	4
	E-LNG	69	72	71	7
	E-Diesel	130	83	85	8
	E-fuel cost in % of IEA	131 %	100 %	102 %	
TO BE	VLSFO	11		11	
	E-Ammonia	30	17	22	2
	E-LNG	42	33	32	3
	E-Diesel	83	36	36	3
	E-fuel cost in % of IEA	180 %	100 %	105 %	

Assessment of fuel comparing annual fuel cost in USD per kW installed main engine (170gram/kWh*24*237days/1000*0.6 gives approximately 600 kg per kW)



With low electricity prices, Synthetic E-fuels (which can be used on the existing fleet) will probably come at similar abatement cost as E-hydrogen and E-ammonia



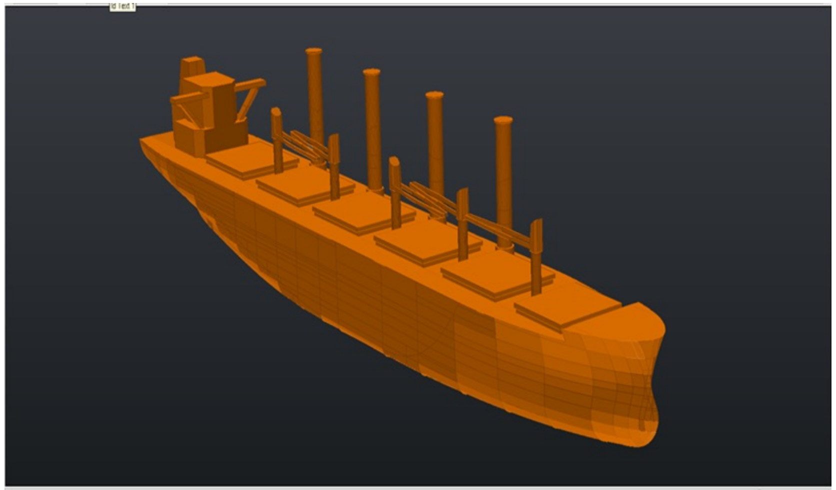
Main observations regarding E- fuels

- Total Renewable electricity today 588 Mtoe, 25 % of global electricity is Green
- Making Electricity Green (keeping 10% nuclear) 588 Mtoe * 65% / 25% = 1500 Mtoe
- Replacing Fossil in cars, trucks and buses 14 207 * 20 % (share of total) * 50% (improve energy utilization) = 1500 Mtoe
- (1500 + 1500 Mtoe) / 588 = 588 %, which implies that Global renewable has to increase with 500 % from 588 to 3588 Mtoe just to replace coal and fossil cars trucks and buses

- If Shipping shall contribute to reducing Global warming it can best do so by improving energy efficiency → Using less energy per ton nm

The Role of Wind Assisted Propulsion

1. Fuel saving from expanding length with 10 – 15% to enable more slender hull, is around 15% for General Cargo, Tank and Bulk from 1 000 – 125 000 dwt
2. Wind assisted propulsion gives an additional 10 – 15% reduction
3. By including CP-Propeller and more flexible power solutions around 30% reduction of fuel and GHG are within reach
   a) So far research and development projects have tended to focus on each of these ones separately and not on the whole.
   b) We now propose a Integrated KPN project with SINTEF Ocean as the host as presented in the next slides with the ambition of reaching this 30% potential reduction of fuel (energy) and GHG emissions .



Wind assisted propulsion on a Slender Bulker designed to utilize the wind: source SINTEF Ocean https://www.forskningsradet.no/sok-om-finansiering/gronn-plattform/

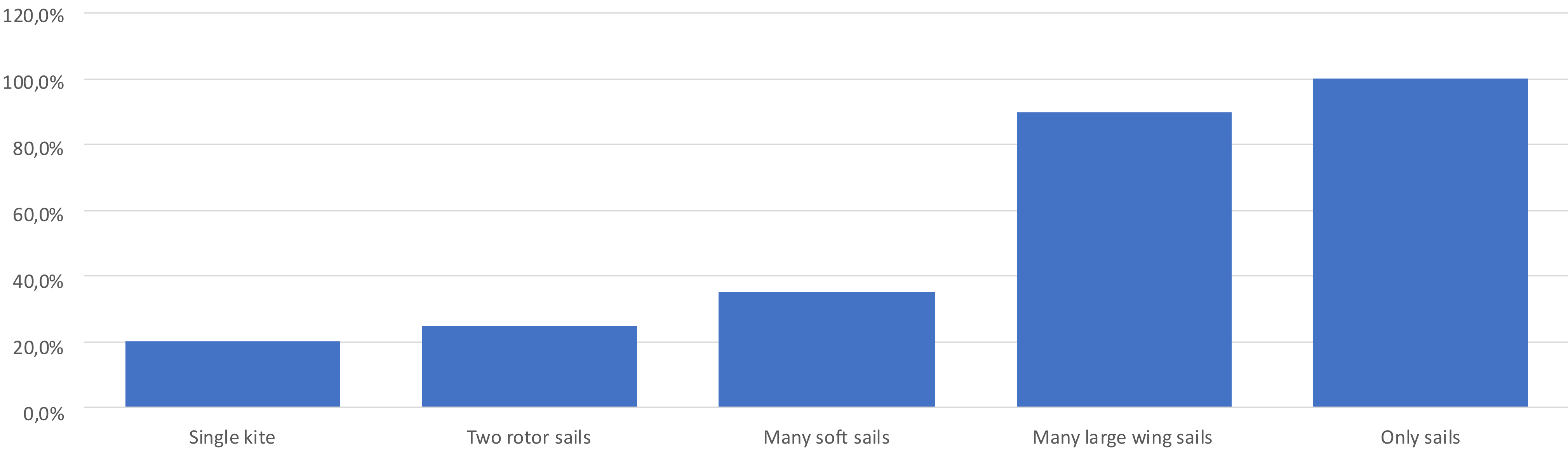
Grønn plattform

Grønn plattform er en ny satsing som gir bedrifter og forskningsinstitutter støtte til forsknings- og innovasjonsdrevet grønn vekst. Vi er ute etter samarbeids-konsortier som kan levere de beste prosjektene, fra forskning og teknologiutvikling, frem til ferdige løsninger. Hensikten er å skape grønne jobber og en mer bærekraftig fremtid. Første fase i Grønn plattform er 1 milliard kroner fordelt over tre år.

ENOVA Forskningsrådet Innovasjon Norge siva

Senter for forskningsdrevet innovasjon
Norges forskningsråd

Examples of fuel savings claims



MARITIME

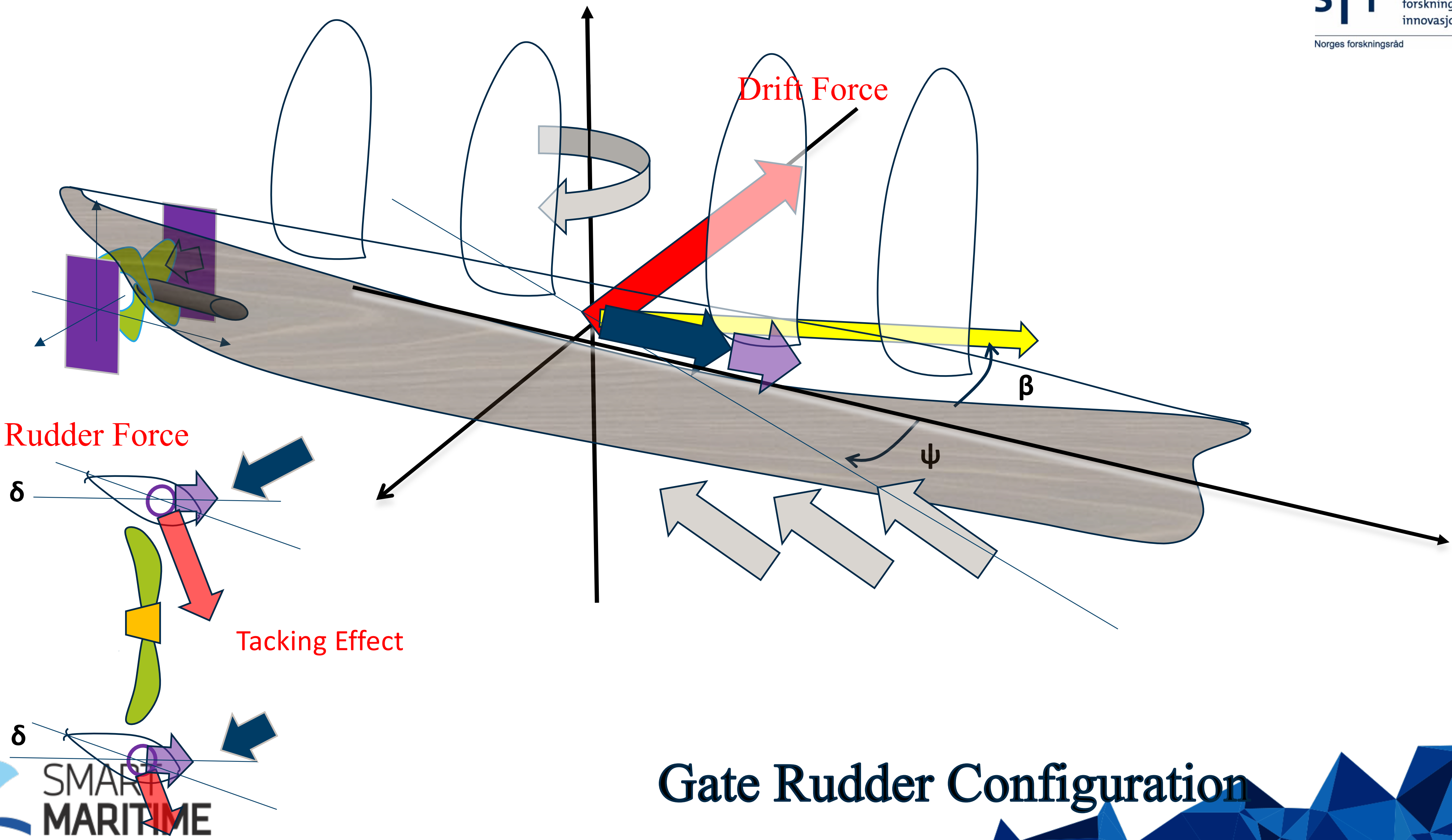
Courtesy of JARLE KRAMER (NTNU), Smart Maritime WEBINAR Wind-assisted propulsion; 2020-11-10

499 type General Cargo 'Shinmon Maru'


509 type General Cargo 'Koshin Maru'


400 TEU Container Ship 'Shigenobu'

SMART MARITIME



Gate Rudder Configuration

GREEN PLATFORM: **WIND**

Wind-driven **I**nnovative **N**orwegian ship **D**esigns

KNOWLEDGE-BUILDING PROJECT

Project owner: SINTEF Ocean
Leader: Elizabeth Lindstad

WORKPACKAGES

- **WP1**: Wind & sail model development
- **WP2**: Hull & propeller design
- **WP3**: Seakeeping & manoeuvrability
- **WP4**: Ship system integration (wind/hull/propeller/machinery/ICS)
- **WP5**: Best practices, rules & regulations for performance validation
- **WP6**: Ship routing & scheduling to utilise wind
- **WP7**: Results exploitation & Green Platform coordination

Total Budget: 30MNOK

INDUSTRY PROJECT

Project Owner: Klaveness
Project leader: Trond Johnsen, SINTEF Ocean

SUB-PROJECTS

- **SP1:** Newbuild Coastal bulker
- **SP2**: Newbuild – Car carrier – VINDSKIP
- **SP3**: Newbuild Combination Carrier
- **SP4**: Retrofit Combination Carrier
- **SP5**: Retrofit – Tanker.
- **SP6**: Retrofit – Car carrier
- **SP7**: Retrofit - Drybulk, Gen.Cargo
- **SP8**: Cruise

Total Budget Industry project: 60-120 MNOK
Public Funding: 30-70MNOK

Questions and Discussion

Thank You!