Life Cycle Assessment (LCA) of Biofuels

International Maritime Statistics Forum

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Agenda

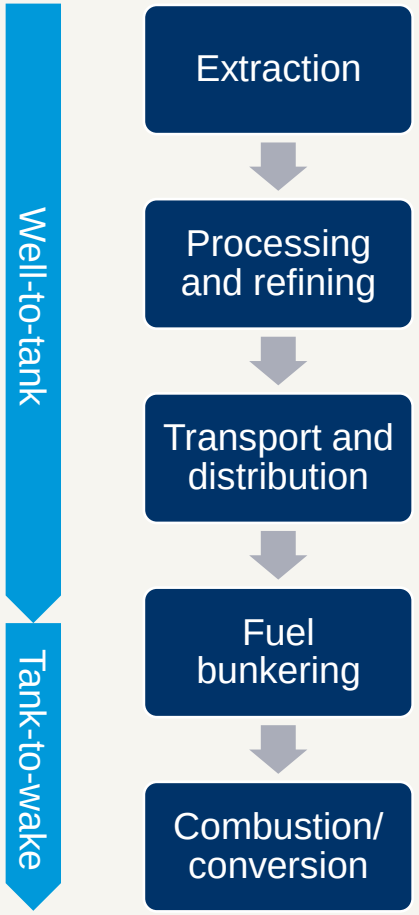
1. Introduction
2. IMO - LCA Guidelines
3. Emissions before Energy Conversion
4. Life Cycle Assessment
5. Final Assessment
6. Outlook

Introduction

- How to calculate the WTT emissions for the regulations?
- How to calculate the TTW emissions for the regulations?
- Which biofuel performs best? (quantitative + qualitative)
- Who is responsible for which emissions?

IMO – LCA Guidelines
Scope

- Application of guidelines by regulations i.e. DCS, EEDI, EEXI
- GHGs included:
  - Carbon dioxide (CO2)
  - Methane (CH4)
  - Nitrous oxide (N2O)
- Basis: IPCC principles; determines which emissions are the responsibility of the international shipping sector
- Even if the WtT emissions are not accounted for in the international shipping sector, it is important to be aware of the sustainability of the fuels used to make informed decisions



Source: ISWG-GHG 9/WP.1

IMO – LCA Guidelines
GHG Emission Factor

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WTW GHG emission factor

$$GHG_{WTW} = LCV_F * GHG_{WTT} + GHG_{TTW}$$

GHG_{WTT} The Well-to-Tank GHG emissions factor (t CO2eq/GJ) for fuel or electricity, set based on the FLL

LCV_F: The lower calorific value for the relevant fuel

TTW GHG emission factor

$$GHG_{TTW} = S_F * C_F + GWP_M * M_{EF} + GWP_N * N_{EF}$$

S_F: The carbon source factor of the specific fuel

C_F: The conversion factor between fuel consumption and CO2 emission (t CO2/t fuel)

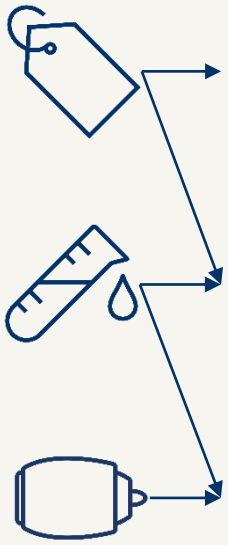
M_{EF}: The methane emission factor (t CH4/t fuel)

N_{EF}: The nitrous oxide emission factor (t N2O/t fuel)

GWP_M: Global warming potential for CH4, equals to 28 for 100-year time horizon

GWP_N: Global warming potential for N2O, equals to 265 for 100-year time horizon

Dependencies of Factors



WtT GHG factors and other sustainability aspects

Determined by FLL

TtW CO2 factors

Determined by fuel type and FLL

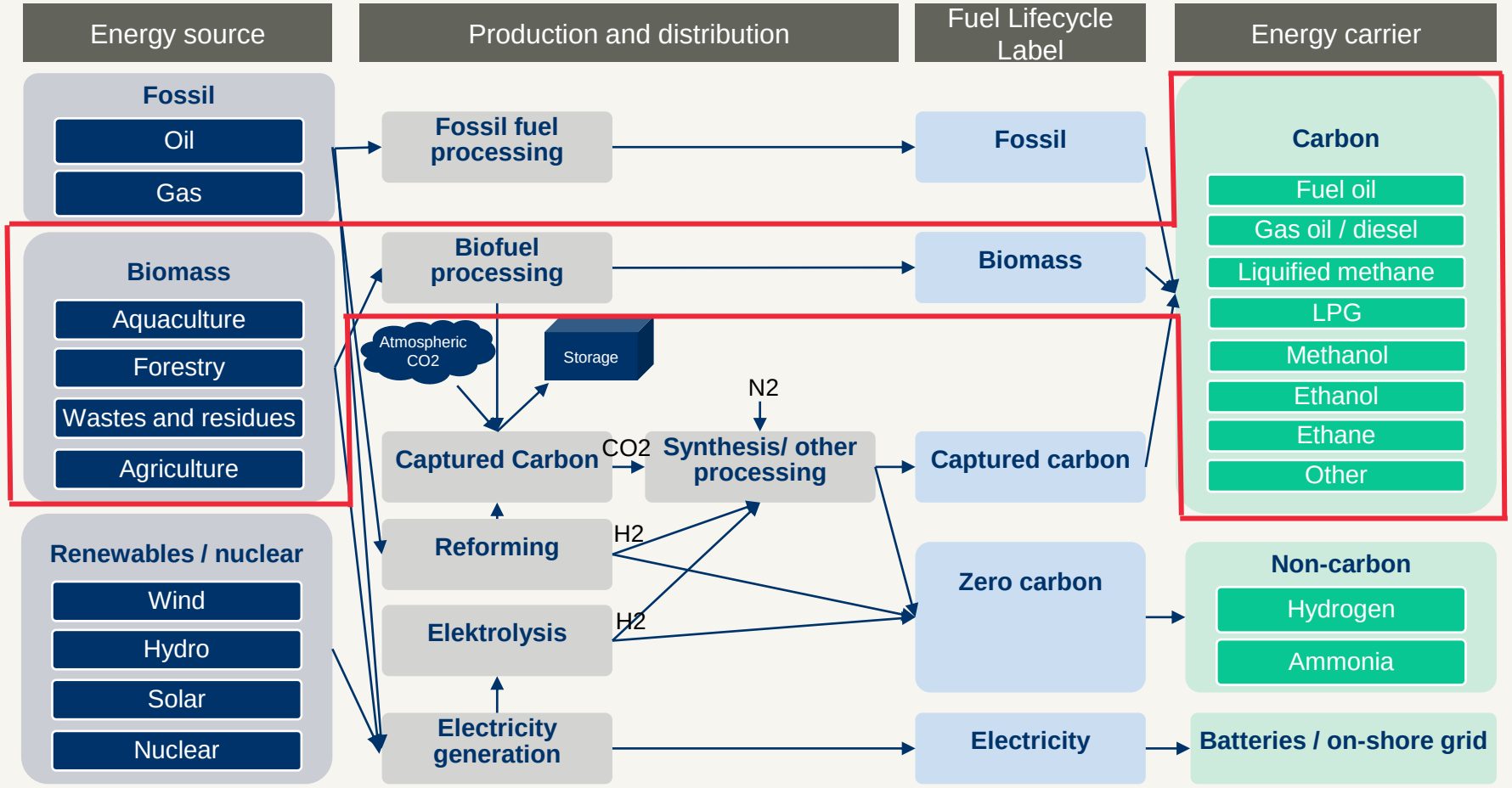
TtW CH4 and N2O factors

Determined by fuel and engine generation and type

Source: ISWG-GHG 9/WP.1

IMO – LCA Guidelines

Well-to-Tank Pathway and Labels



Source: ISWG-GHG 9/WP.1,Own illustration

IMO – LCA Guidelines
Well-to-Tank Methodology

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$$E = e_{ec} + e_l + e_p + e_{td} + e_u - e_{sca} - e_{ccs} - e_{ccr}$$

E	e_{ec}	e_l	e_p	e_{td}	e_u	e_{sca}	e_{ccs}	e_{ccr}
total emissions from the production of the fuel before energy conversion	emissions from the **extraction** or **cultivation** of raw materials	annualised emissions from **carbon stock changes** caused by land-use change	emissions from **processing**	emissions from **transport** and **distribution**	emissions from the fuel in **use**	emission **savings** from **soil carbon accumu-lation** via improved agricultural management	emission **savings** from **CO2 capture** and **geological storage**	emission **savings** from **CO2 capture** and **replace-ment**

IMO – LCA Guidelines
Parameters

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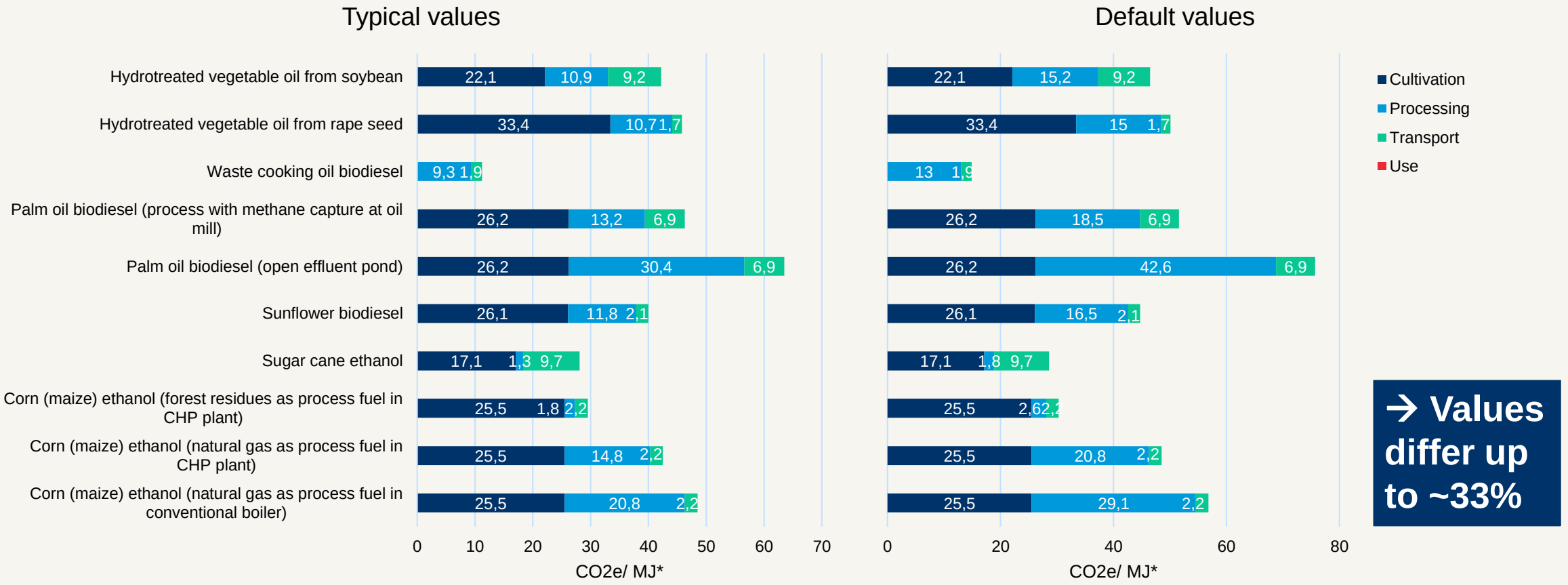
Parameters for analysis

	LCV $(\frac{MJ}{g})$	$CO_{2e\,WtT}$ $(\frac{gCO_{2e}}{MJ})$	S_f*	C_{fCO2} $(\frac{gCO_2}{gFuel})$	C_{fCH4} $(\frac{gCH_4}{gFuel})$	C_{fN_2O} $(\frac{gN_2O}{gFuel})$
VLSFO	0,041	13,2	1	3,206	0,0005	0,0018
Liquid biofuels:						
▪ Ethanol	0,0268	Ref. to Directive (EU) 2018/2001	0	1,913	0,0005	0,0018
▪ Biodiesel	0,0372			2,834		
▪ HVO	0,044			3,115		

*In case of a blended fuel *SF* should be calculated as the weighted average of the mass of the various blend stocks

Source: Directive 2009/16/EC

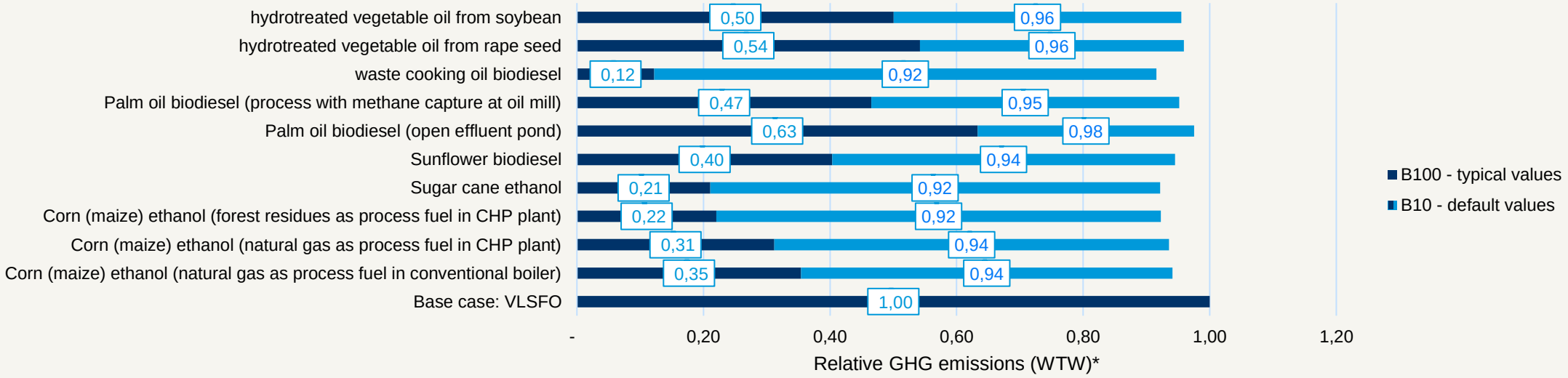
Emissions before Energy Conversion



→ Values differ up to ~33%

*Own illustration

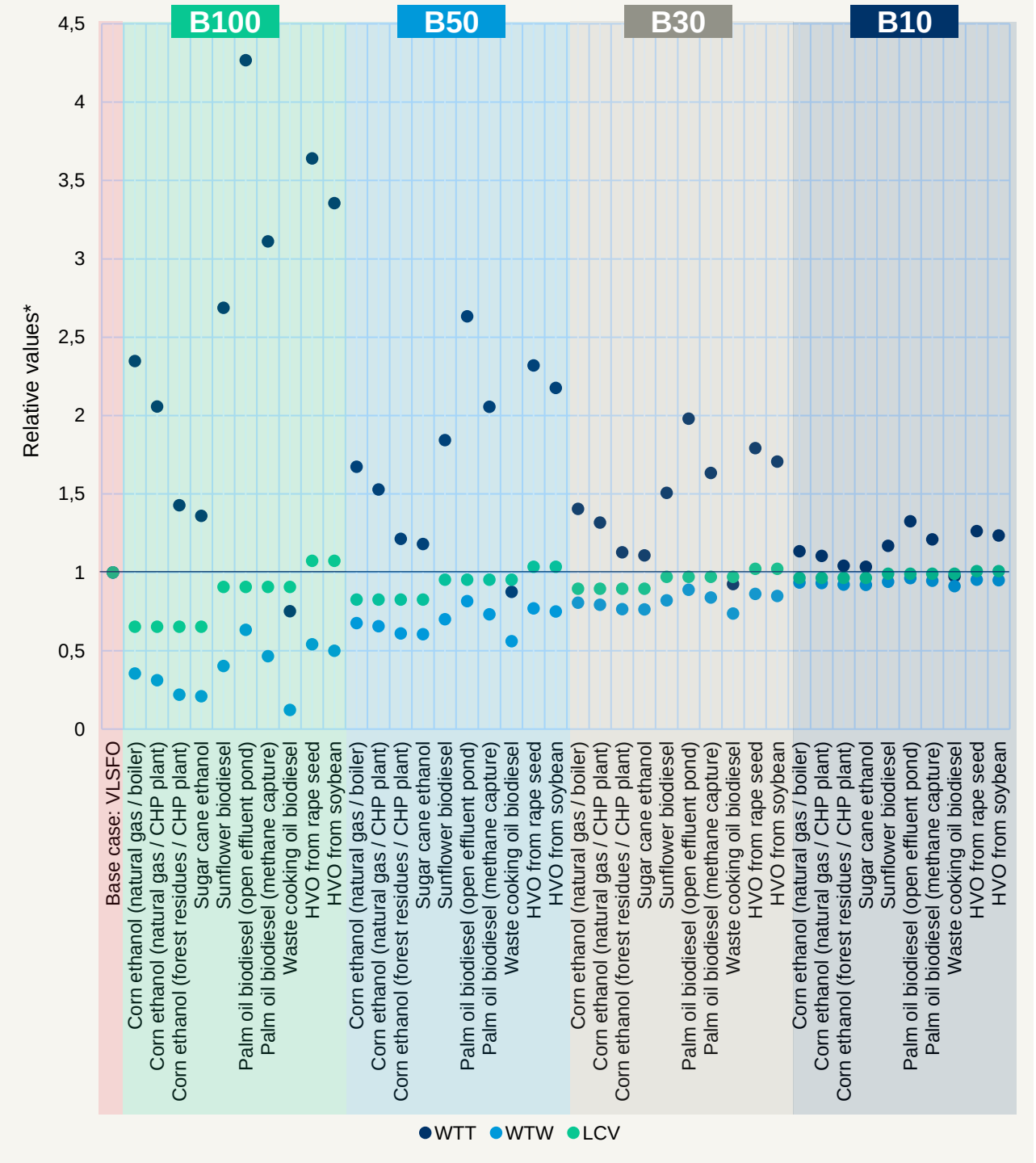
Life Cycle Assessment
Relative comparison B100 + B10



WTW comparison

- Up to rd. 650% higher GHG emissions (waste cooking oil)
- Currently no container vessels operating on B100; succesfully implemented in the bulk sector
- Commonly used blends: B10 – B30
- Solution: Application of Mass Balance Concept

*Own illustration



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Final Assessment

- <u>Quantitative evaluation:</u>
  - WTT values of biofuel higher than VLSFO (except waste cooking oil)
  - Palm oil biodiesel → highest WTT emissions
  - Maximum LCV deviation of HVO + biodiesels <10%; whereas ethanol is only rd. two-thirds of VLSFO
- <u>Qualitative evaluation:</u>
  - Ethical evaluation: No food for fuel, working conditions (i.e. palm oil)

→Waste cooking oil performs best (K+N biofuel concept)

*Typical values reflected
**Own illustration

Outlook

- MEPC 80 (July 2023) → Finalisation of LCA guidelines for different fuel types
- New fuels soon available → no blends
- Many uncertainties (more or less emissions due to transportation / production etc.)
- Who is accountable for what (WTT + TTW emissions)?

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