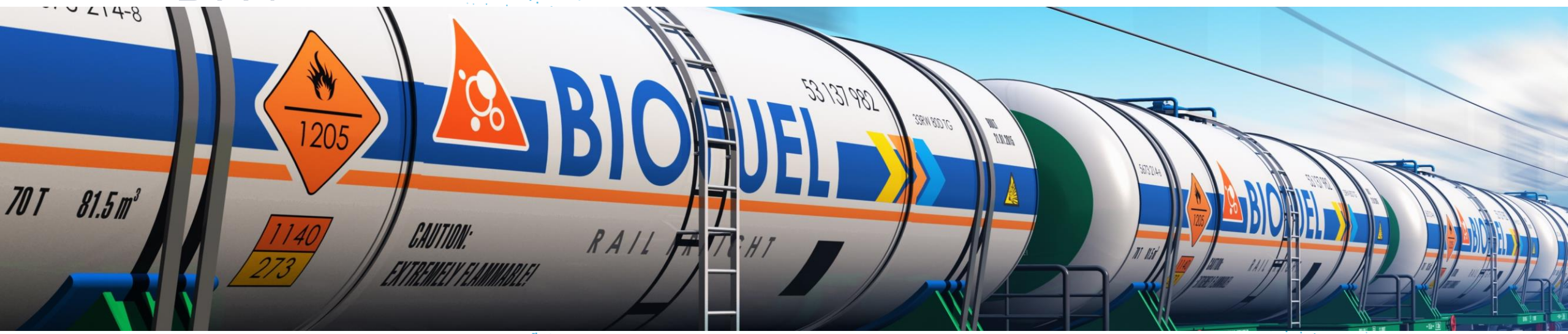


Alternative Fuels

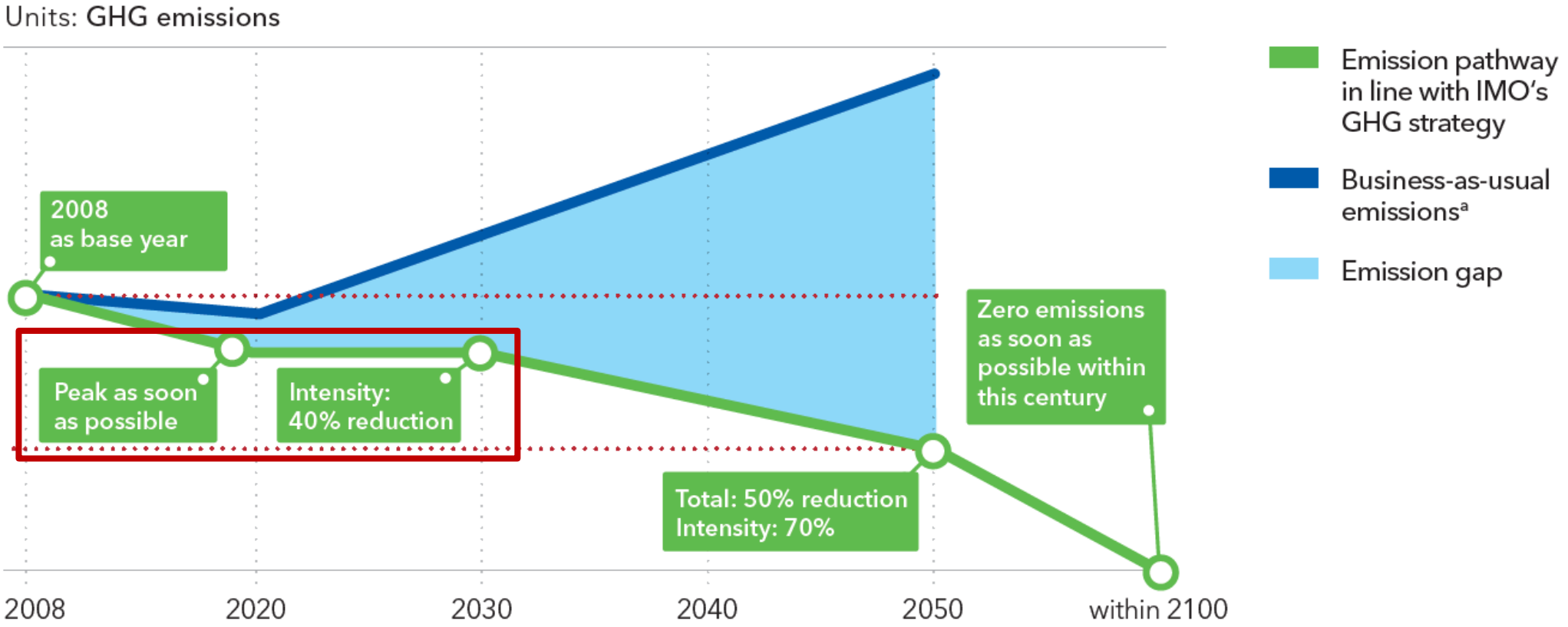
Biofuels in international shipping

Dr. Fabian Kock

11 June 2021

Biofuels:
Decarbonization strategy of IMO

IMO strategy on GHG reductions – vision and ambitions



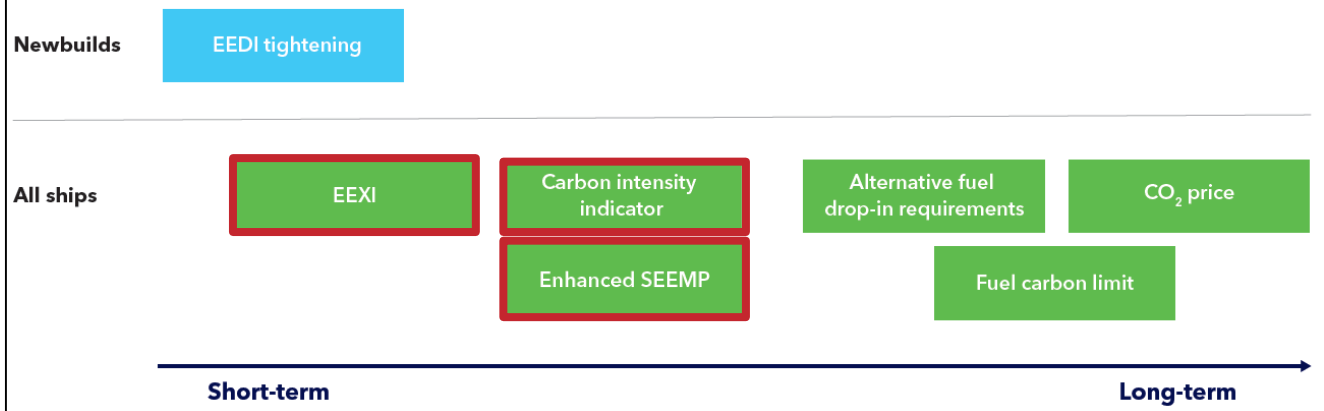
Total: Refers to the absolute amount of GHG emissions from international shipping.
Intensity: Carbon dioxide (CO_2) emitted per tonne-mile.
[a] Note that the the business-as-usual emissions are illustrative, and not consistent with the emissions baseline used in our modelling (Chapter 6).

Outcome of MEPC 75 (November 2020): New short-term measures for GHG

Two new short-term measures have been introduced for all ships (NB and ships in operation):

1. **Energy Efficiency Existing Ship Index (EEXI)**
2. **Operational carbon intensity reduction requirements, based on a new operational Carbon Intensity Indicator (CII)**

Indicative timeline for developing and implementing possible global policy measures - the list of measures is not exhaustive.



EEDI: Energy Efficiency Design Index
EEXI: Energy Efficiency Design Index for Existing Ships
SEEMP: Ship Energy Efficiency Management Plan

Mandatory for each vessel from 2023:

Compliant EEXI value & EEXI Technical File to be approved by class
Classification Survey (first annual survey) – new IEEC certificate

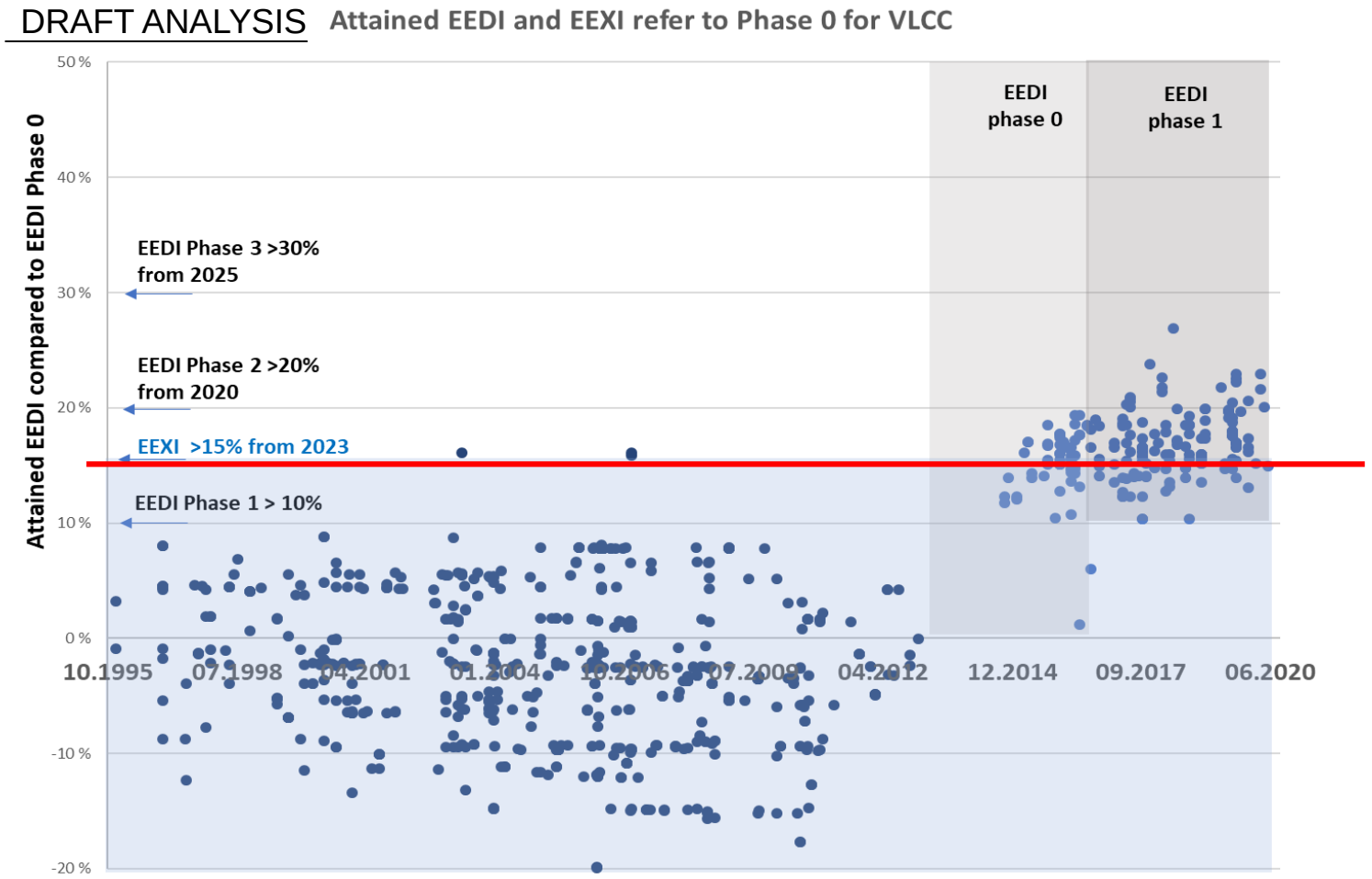
	EEXI	CII
Limits/reduction rates	Agreed	Work in progress
Calculation guidelines	Work in progress	Work in progress

Overview of applicability of regulations in MARPOL

Ship type/characteristics		Reg. 22: Attained EEDI	Reg. 24: Required EEDI	Reg. 23: Attained EEXI	Reg. 25: Required EEXI	Reg. 26: Approved SEEMP and audits	Reg. 27: Data Collection System	Reg. 28: CII rating, req. SEEMP content
Conventional propulsion	Bulk carrier	>= 400 GT	>= 10000 DWT	>= 400 GT	>= 10000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Gas carrier	>= 400 GT	>= 2000 DWT	>= 400 GT	>= 2000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Tanker	>= 400 GT	>= 4000 DWT	>= 400 GT	>= 4000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Container ship	>= 400 GT	>= 10000 DWT	>= 400 GT	>= 10000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	General cargo ship (except livestock carrier, barge carrier, heavy load carrier, yacht carrier, nuclear fuel carrier)	>= 400 GT	>= 3000 DWT	>= 400 GT	>= 3000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Refrigerated cargo carrier	>= 400 GT	>= 3000 DWT	>= 400 GT	>= 3000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Combination carrier	>= 400 GT	>= 4000 DWT	>= 400 GT	>= 4000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Ro-ro vehicle carrier	>= 400 GT	>= 10000 DWT	>= 400 GT	>= 10000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Ro-ro cargo ship	>= 400 GT	>= 1000 DWT	>= 400 GT	>= 1000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Ro-ro passenger ship	>= 400 GT	>= 250+ DWT and >=400 GT	>= 400 GT	>= 250 DWT and >=400 GT	>= 400 GT	>= 5000 GT	>= 5000 GT
	Cruise ship	>= 400 GT	N/A	>= 400 GT	N/A	>= 400 GT	>= 5000 GT	>= 5000 GT
	Passenger ship (except ro-ro-passenger and cruise)	>= 400 GT	N/A	N/A	N/A	>= 400 GT	>= 5000 GT	N/A
	Other ship with conventional propulsion, (e.g. heavy load carrier, livestock carrier, offshore)	N/A	N/A	N/A	N/A	>= 400 GT	>= 5000 GT	N/A
LNG carrier with any propulsion system		>= 400 GT	>= 10000 DWT	>= 400 GT	>= 10000 DWT	>= 400 GT	>= 5000 GT	>= 5000 GT
Cruise ship with non-conventional propulsion		>= 400 GT	>= 25000 GT	>= 400 GT	>= 25000 GT	>= 400 GT	>= 5000 GT	>= 5000 GT
Livestock carrier, barge carrier, heavy load carrier, yacht carrier, nuclear fuel carrier and passenger ship with non-conventional propulsion, and Category A Polar Code ship		N/A	N/A	N/A	N/A	>= 400 GT	>= 5000 GT	N/A
Other ship with non-conventional propulsion		N/A	N/A	N/A	N/A	>= 400 GT	>= 5000 GT	>= 5000 GT
Platforms including FPSOs and FSUs and drilling rigs		N/A	N/A	N/A	N/A	N/A	N/A	N/A

EEXI: A large number of vessels will have to implement improvement measures to be compliant on 1. Jan 2023

DRAFT ANALYSIS



This graph can be taken as representative for other vessel segments

Good to know:

Details were agreed at MEPC 75; subject to MEPC 76 adoption

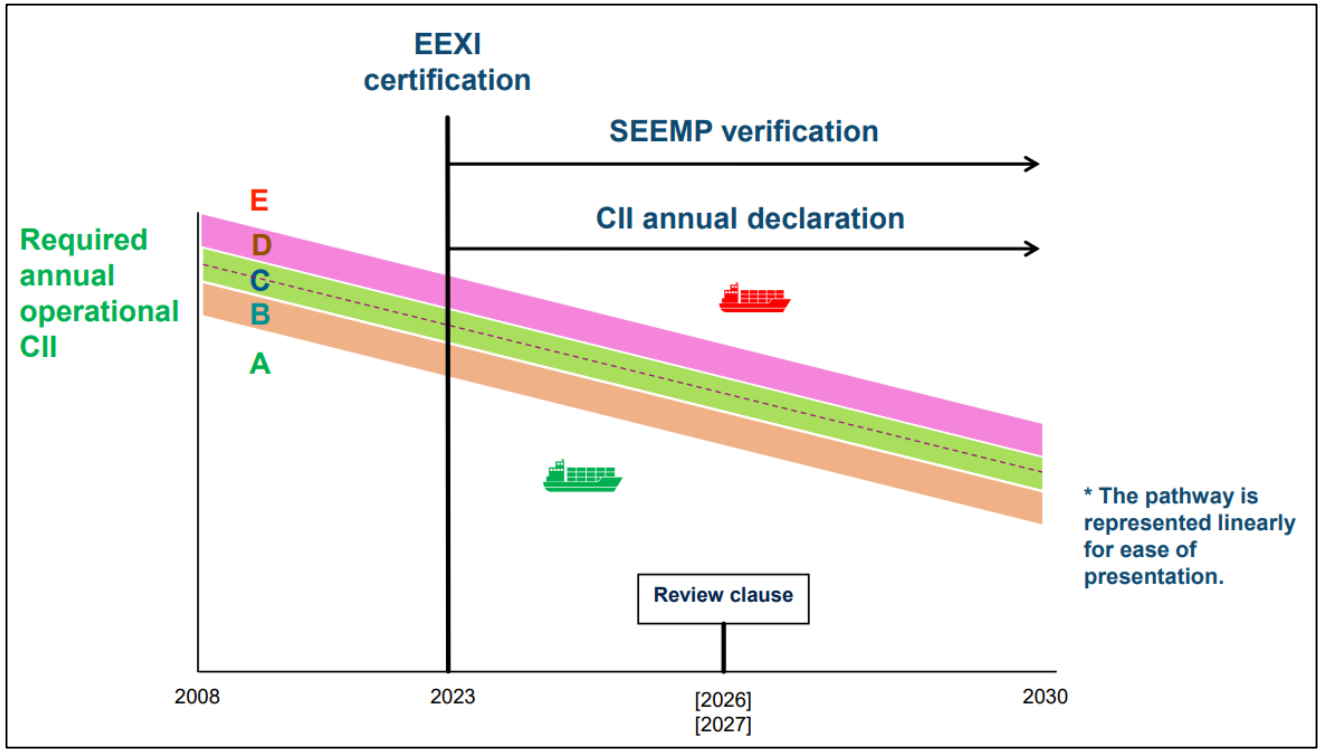
- **Majority** of (older) vessels will have to **implement technical measures before 1. Jan 2023** to be EEXI-compliant
- Most likely measures **Engine Power Limitation** or **Shaft Power Limitation**

Potential of different improvement measures (design)

Description	**Power limitation** [% rel. to MCR]	**Ship speed loss** [% rel. to V_S]	**EEXI Improvement** [%]
Engine power limitation	up to 50	~21	~37
Description	**SFOC Improvement** [%]	**Different C_F** [%]	**EEXI Improvement** [%]
Fuel change from MDO to LNG	10	15	25
Description	**Power reduction** [% rel. to P_{ME}]	**Ship speed reduction** [% rel. V_{ref}]	**EEXI Improvement** [%]
Rotor sails (2 units) on Long Range 2 tanker	4		3.8
Installation of shaft generator	6	1.7	5.6
Combination of both installations	10	1.7	9.5
Description	**DWT increase** [%]	**att. EEXI gain** [%]	**EEXI Improvement** [%]
Deadweight increase	5	3.7	1.5
	10	7.1	3.0
Description	**Power reduction** [% rel. to P_{ME}]	**Ship speed increase** [% rel. V_{ref}]	**EEXI Improvement** [%]
Energy saving device (e.g. PBCF, duct)	1	0.3	0.3
	4	1.4	1.3
	7	2.4	2.3
	10	3.5	3.3

Operational measure: Enhanced SEEMP

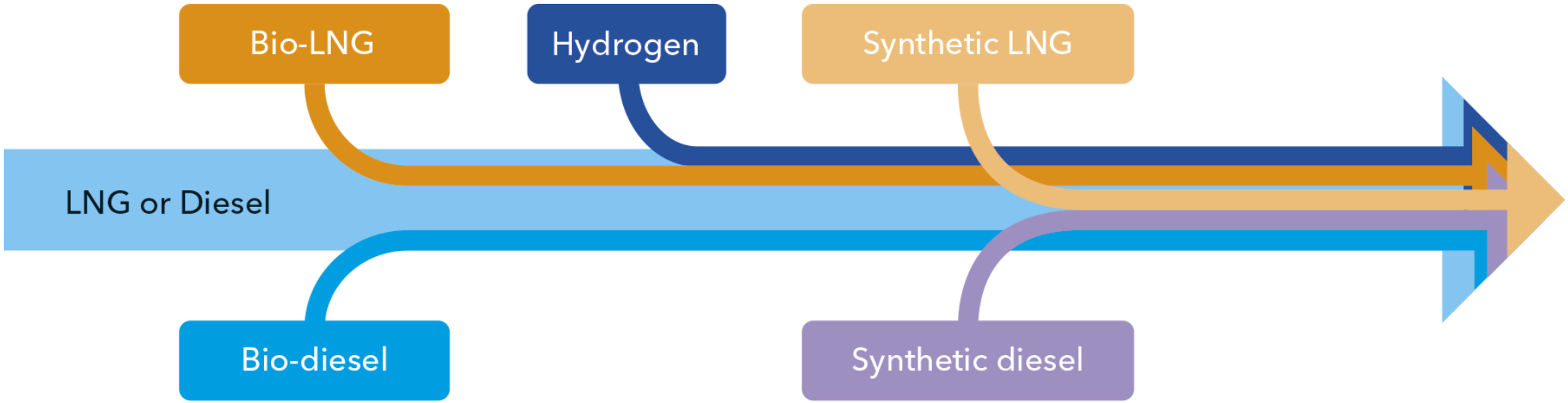
- Mandatory elements added to the SEEMP
  - Measuring a **Carbon Intensity Indicator (CII)**
  - Setting a **mandatory CII target** in line with IMO ambitions
- Operational: Enhanced SEEMP with mandatory Carbon Intensity Indicator (CII) rating scheme (A-E)



- Ships must document the CII and at verification audits prove that they are **compliant with reduction trajectory** towards ~40% in 2030
- Application scope & handling of **inferior ships** to be resolved
- **Technical guidelines** to be developed – these include definitions, the ship specific reduction rates and calculation guidelines

Alternative Fuels with low carbon content will play a major role

Newbuildings: How to prepare for decarbonization?

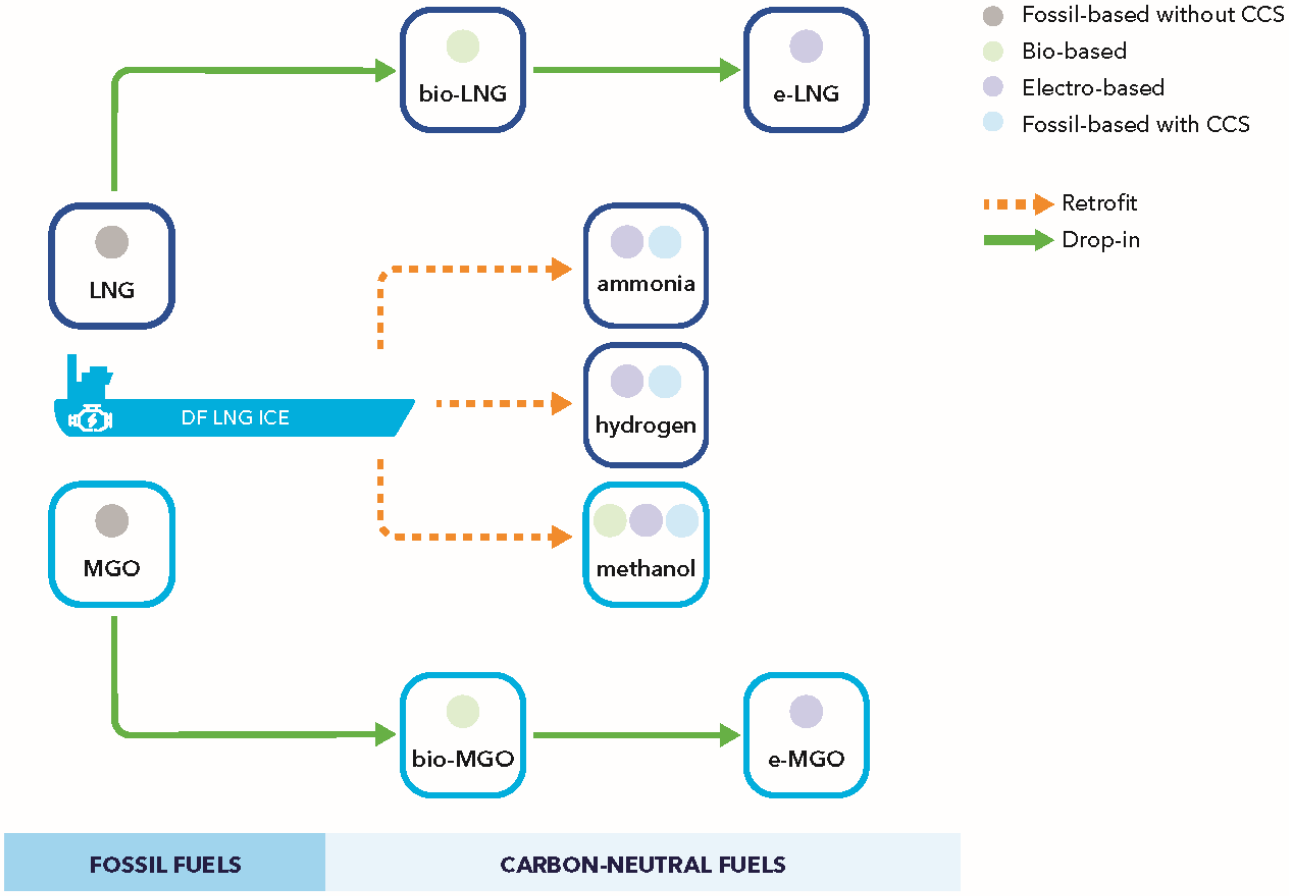


A vessel powered by dual fuel engines that can burn LNG and MGO has different options for fuel shifts, allowing for a gradual transition.

Alternative fuel-ready solutions

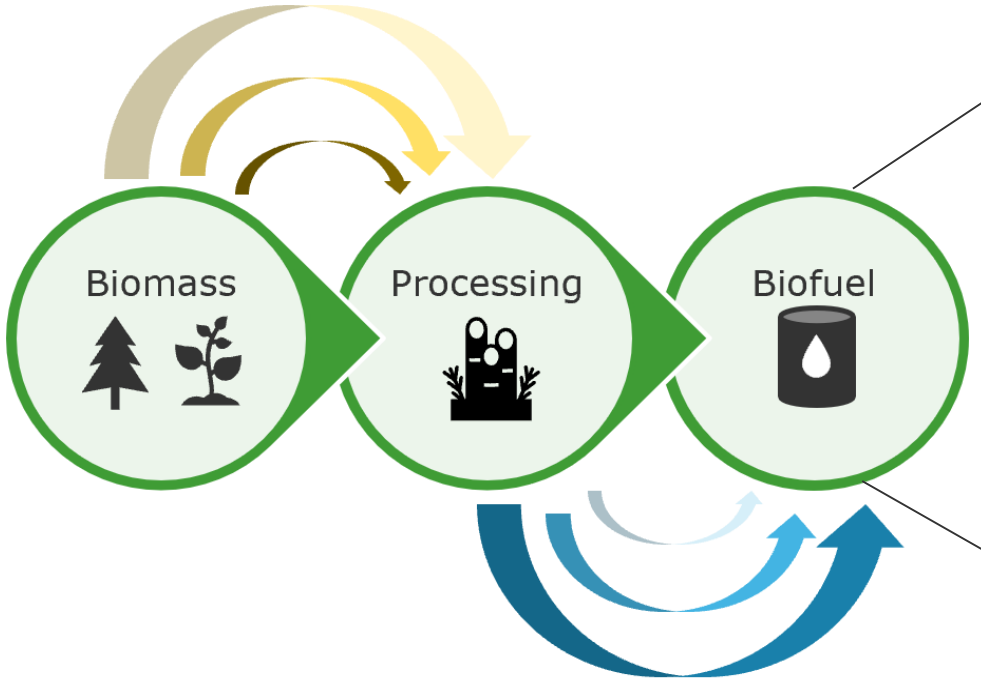
Building the vessel with conventional fuel technology but preparing it to allow a less-costly conversion later.

Assessment can be made to evaluate which preparations to incorporate in the newbuilding and which to be left for a later conversion.



Bio Fuels:
Introduction

Types of Biofuels used in maritime applications



FAME
Hydrogen
LBG (Methane)
Methanol
Ethanol
DME
Ammonia
SVO
Upgraded pyrolysis oil
F-T diesel
HVO

+ more

The term ***biofuel*** is very generic

The ***biofuel family*** is very diverse

HVO: Hydrotreated Vegetable oil
SVO: Straight Vegetable Oil
DME: Dimethyl Ether
FAME: Fatty Acid Methyl Ester
F-T diesel: Fischer-Tropsch diesel
LBG: Liquefied biogas

Current marine usage

- The use of biofuels today in the maritime industry is **very limited**, mostly piloting/test projects

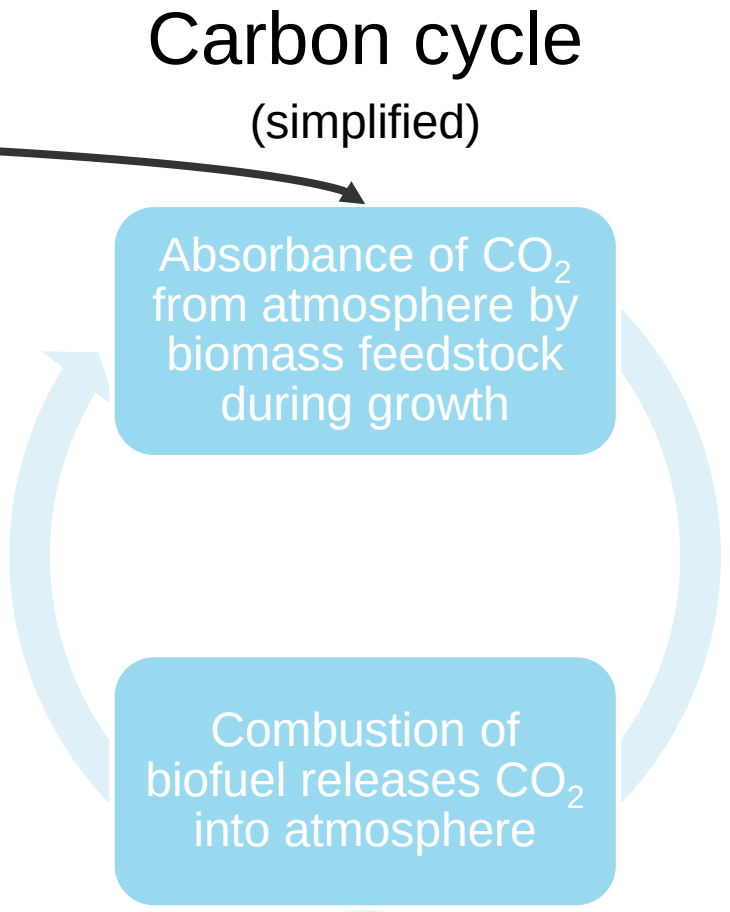
- Some shipping companies have, however, stated that they will use significant amounts of **blends** consisting of fossil fuels and biofuels on a **regular basis**

HURTIGRUTEN	From 2020; will regularly use an LNG/LBG blend on some of its vessels. Largest marine use of LBG to date
msc	Will start using a 30% biofuel blend on some container vessels calling at Rotterdam
CMA CGM	Reportedly purchased tens of thousands of tons of advanced biofuel supplied by Shell made from used cooking oil

LBG: Liquefied Biogas

Why biofuels?

+ Potential to reduce GHG emissions
+ technical compatibility (not all)
+ high energy-density (not all)
+ sulphur-free



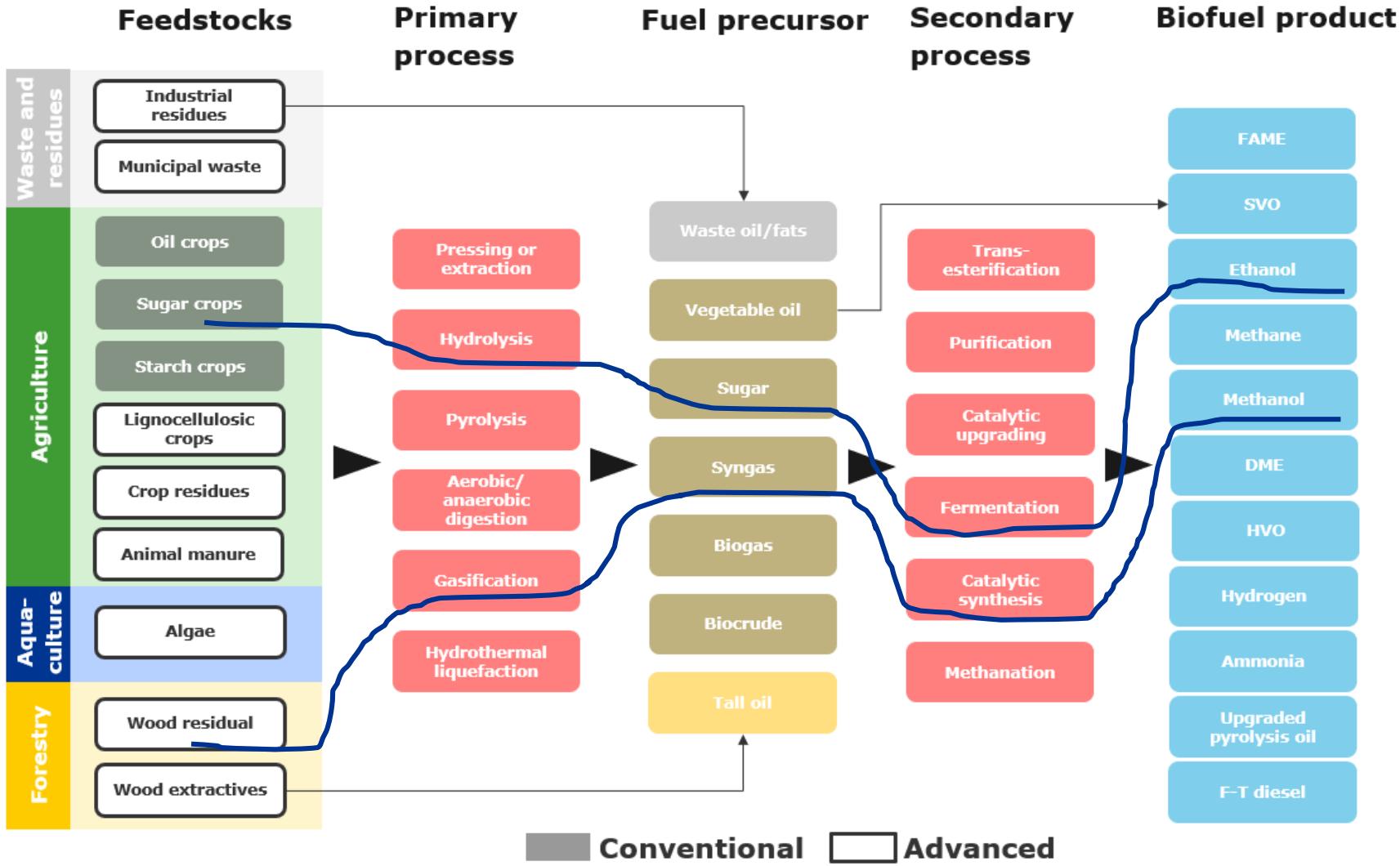
Bio Fuels:
Production, sustainability and economics

Biofuel production pathways

Biofuels are produced from **different feedstock sources**

Biofuels made from oil, sugar, and starch crops are often designated as *conventional,* contrary to *advanced* biofuels

Advanced biofuels score higher on sustainability



Sustainability (1)

- Food vs. fuel debate
  - A rise in food-commodity prices, coincided with an upscale in biofuel production

- Land-usage change (direct & indirect)
  - Release of carbon stocks (direct)
  - Displacement of food-production (indirect)

Sustainability (2)

Environment Nature

Norway Is The First Country To Ban Palm Oil Based Biofuel

by Andrea D. Steffen January 27, 2019

SHARE 0

Norway is the first country to enforce a ban on palm oil-based biofuel. The nation's parliament announced last week that it will no longer be permitted in Norway. The move aims to thwart the destruction of Indonesian rainforests razed for palm oil plantations. The country's biofuel industry will have until 2020 to phase out the oil.

Nils Hermann Ranum of Rainforest Foundation Norway said in a statement:

> *"The Norwegian parliament's decision sets an important example to other countries and demonstrates the need for a serious reform of the world's palm oil industry."*

https://www.intelligentliving.co/norway-ban-palm-biofuel/

DNV

Current production

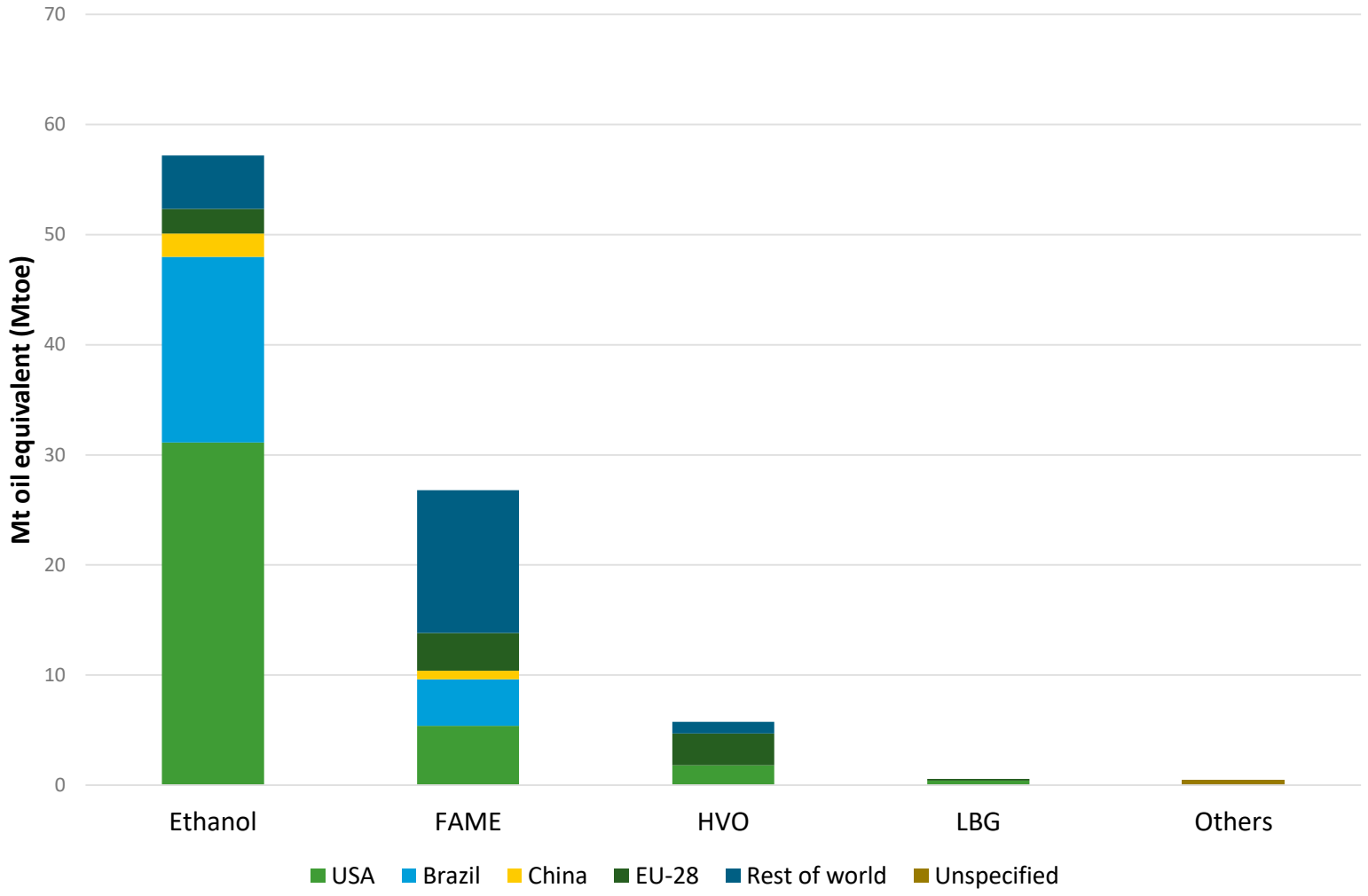
Total production in 2018:

90 Mtoe

Energy consumption of world fleet in 2018:

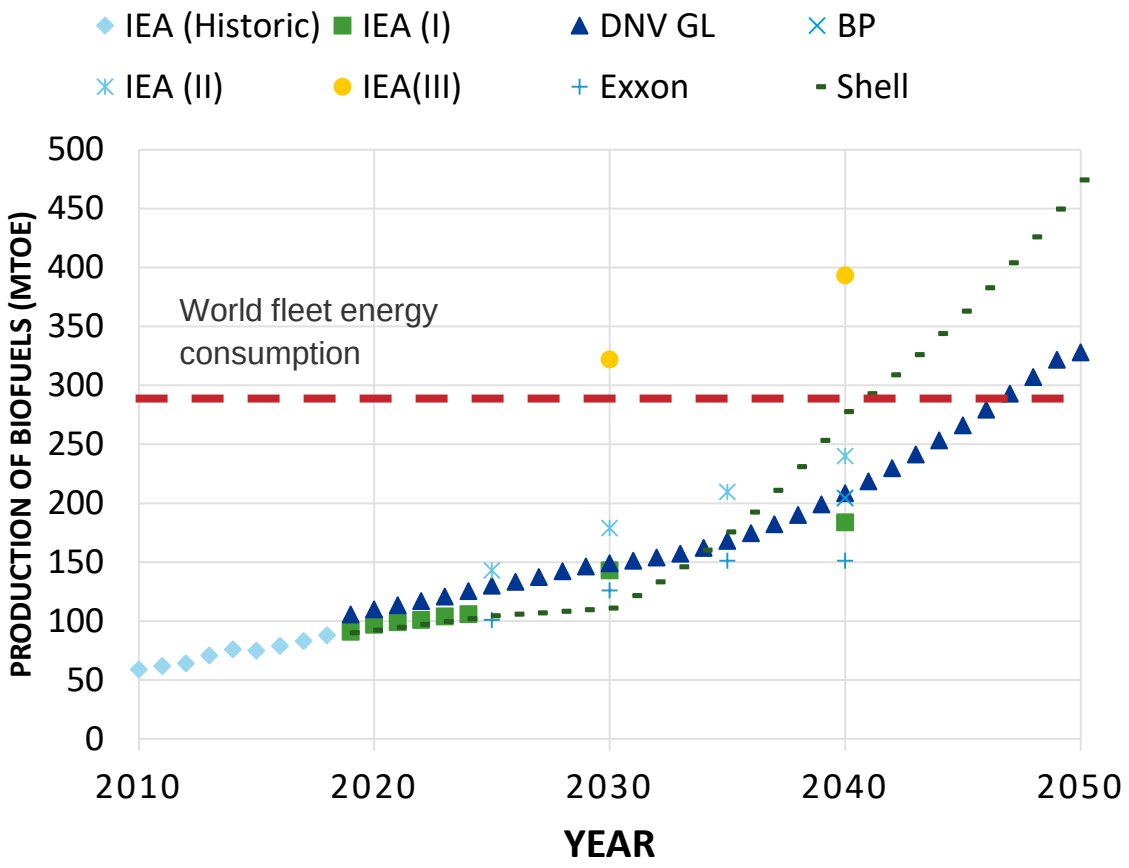
~274 Mtoe

Production of biofuels other than ethanol, FAME, and HVO is low

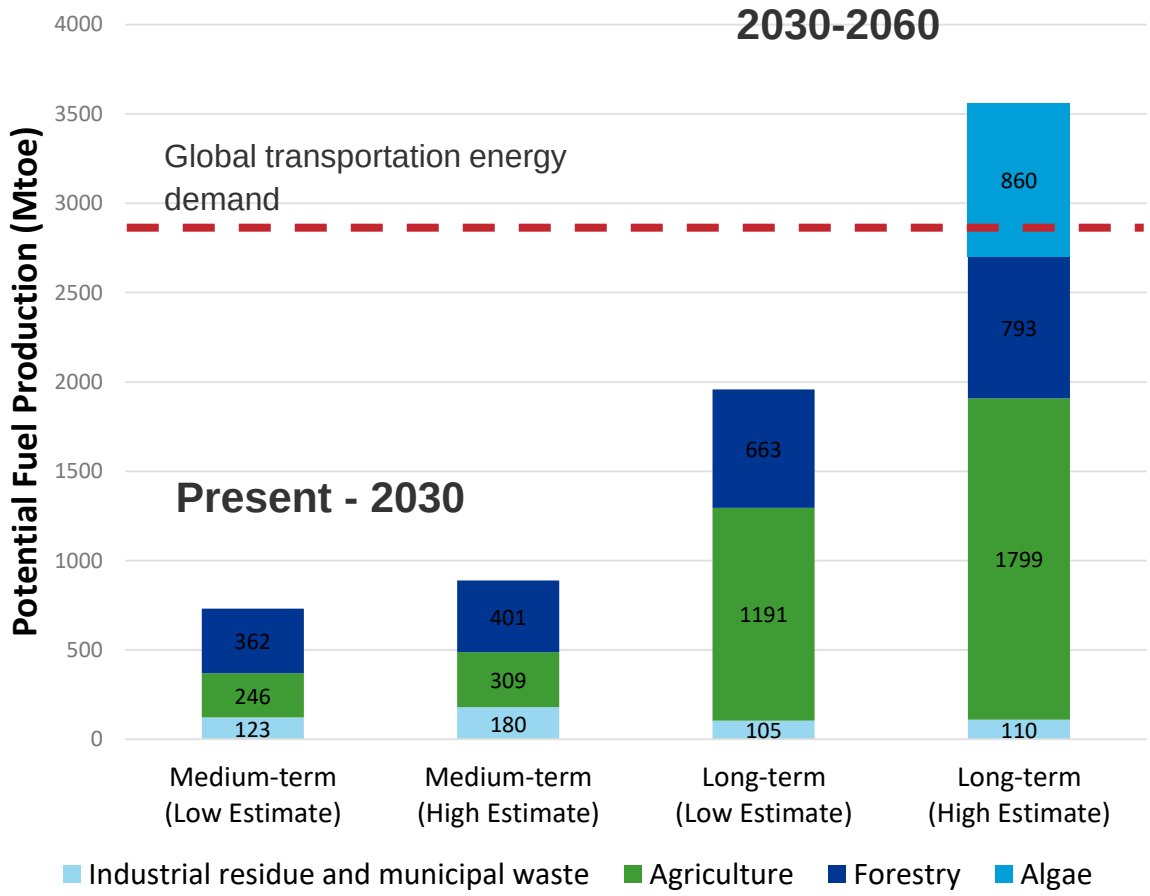


Based on data from (DNV GL, 2019) and (GSR, 2019)

Future outlook



Production forecasts

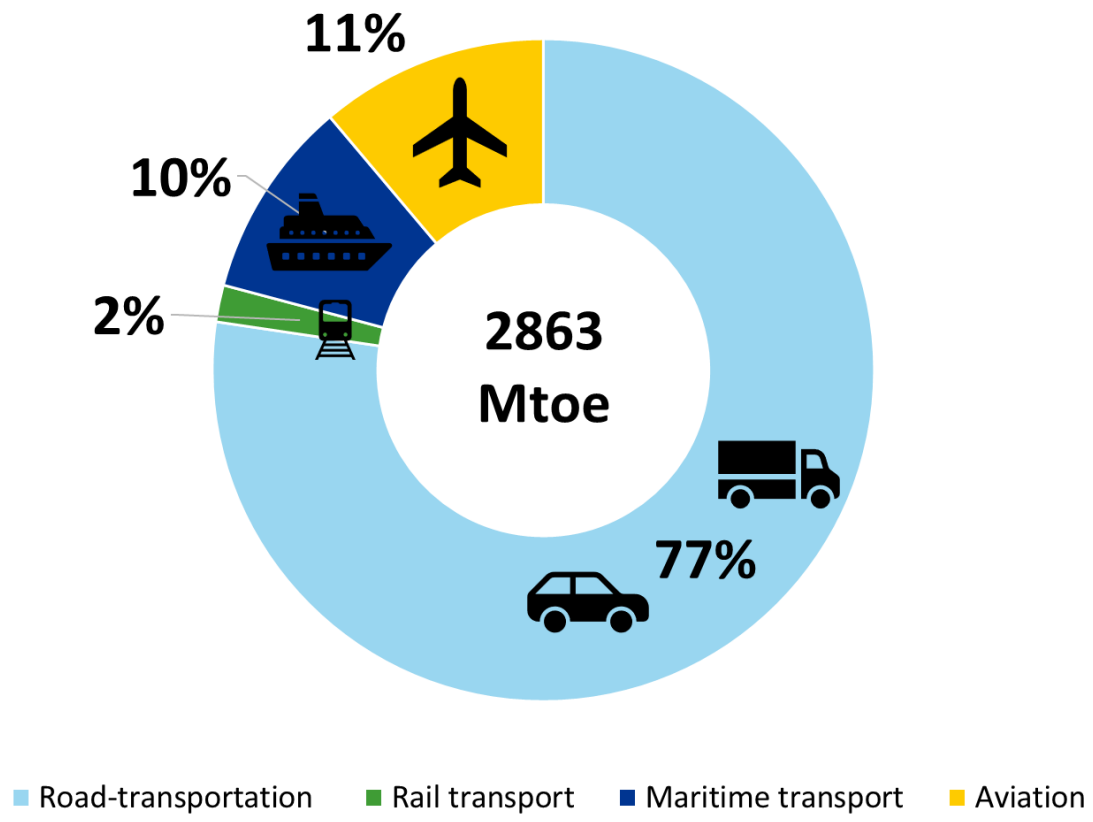


Potential production (annual)

Based on data from various sources

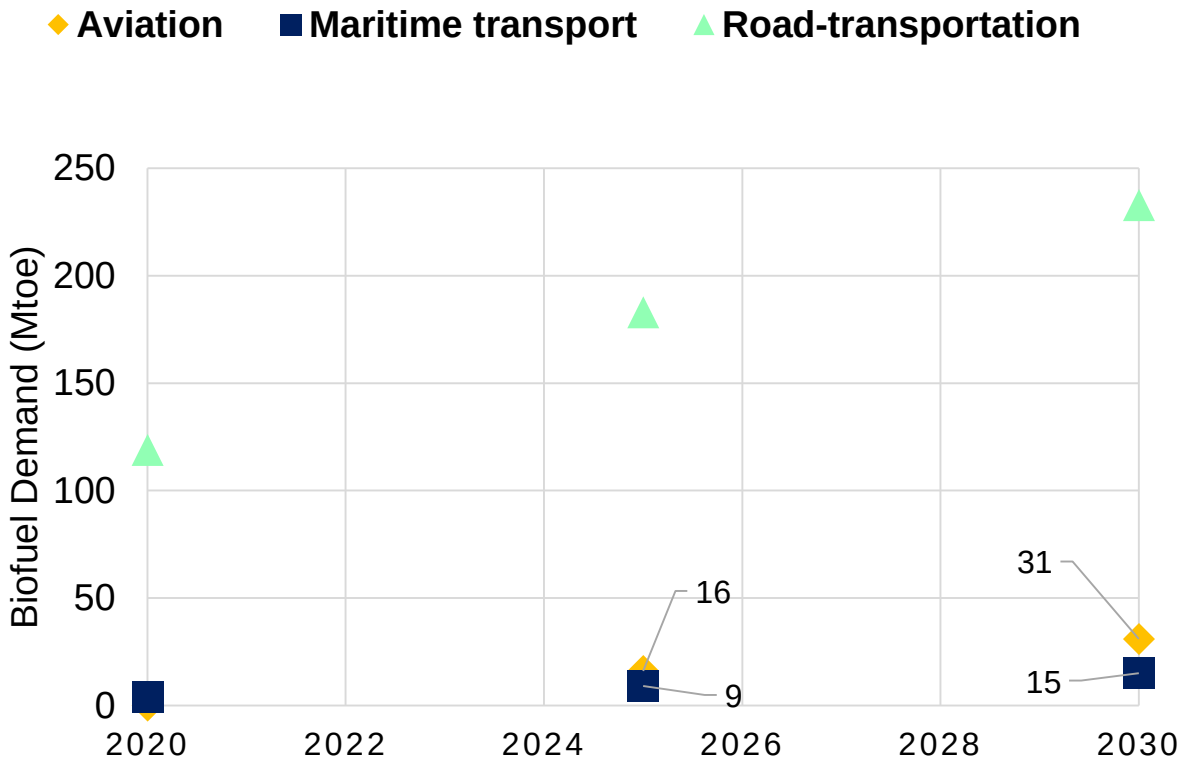
Competition for biofuels

Total transportation energy consumption by sector, 2018



Uptake of biofuels

(IEA's *Sustainable Development Scenario*)

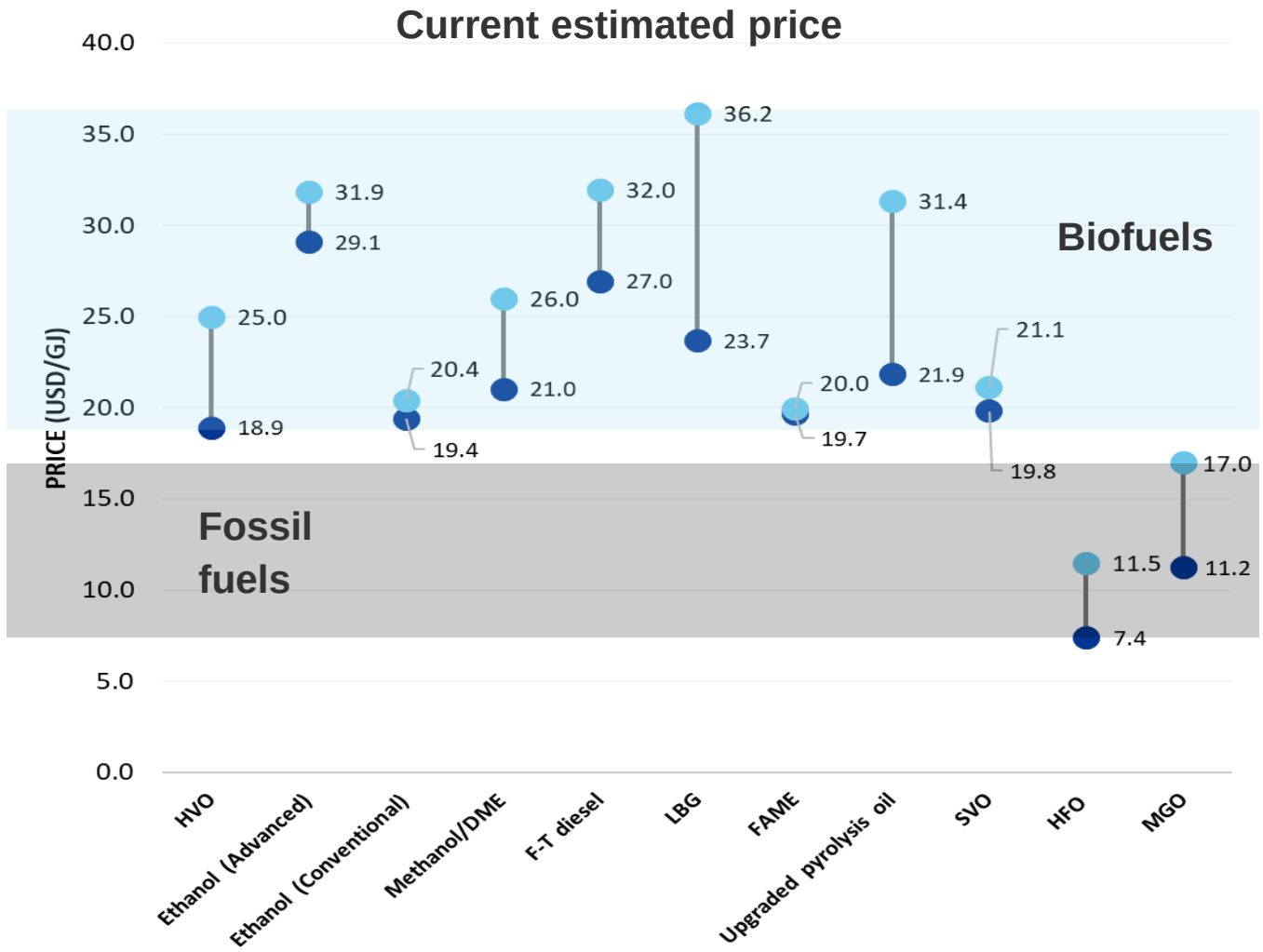


Based on data from (IEA, 2019) and (GSR, 2019)

Economics - Current

Price is a major barrier for uptake of biofuels in shipping

Some biofuels have not been produced at commercial scale yet; therefore high uncertainty in estimated costs



Based on data from various sources

HFO and MGO prices are based on max/min price in Rotterdam in 2018

Bio Fuels:
Regulatory Background

Bio fuels: Benefits “on paper” for the ship operator?

- EEDI and EEXI are **design** related measures
  - Fuel types refer to fuel types defined in EEDI framework
  - No benefit due to operation with biofuels

- IMO DCS: **Fuel Oil Consumption** reporting, **not** CO_2 reporting
  - Fuel types refer to fuel types defined in EEDI framework

- IMO Carbon Intensity Indicator (CII)
  - Details not defined, however discussion on life cycle assessment and Carbon Intensity Code initiated

- MRV: CO_2 monitoring, reporting and verification
  - Fuel type same as IMO, but “Appropriate emission factors shall be applied for biofuels”.

Type of fuel	Reference	Lower calorific value (kJ/kg)	Carbon content	C_F (t-CO_2/t-Fuel)
1 Diesel/Gas Oil	ISO 8217 Grades DMX through DMB	42,700	0.8744	3.206
2 Light Fuel Oil (LFO)	ISO 8217 Grades RMA through RMD	41,200	0.8594	3.151
3 Heavy Fuel Oil (HFO)	ISO 8217 Grades RME through RMK	40,200	0.8493	3.114
4 Liquefied Petroleum Gas (LPG)	Propane	46,300	0.8182	3.000
	Butane	45,700	0.8264	3.030
5 Liquefied Natural Gas (LNG)		48,000	0.7500	2.750
6 Methanol		19,900	0.3750	1.375
7 Ethanol		26,800	0.5217	1.913

Fuel types defined in IMO EEDI framework

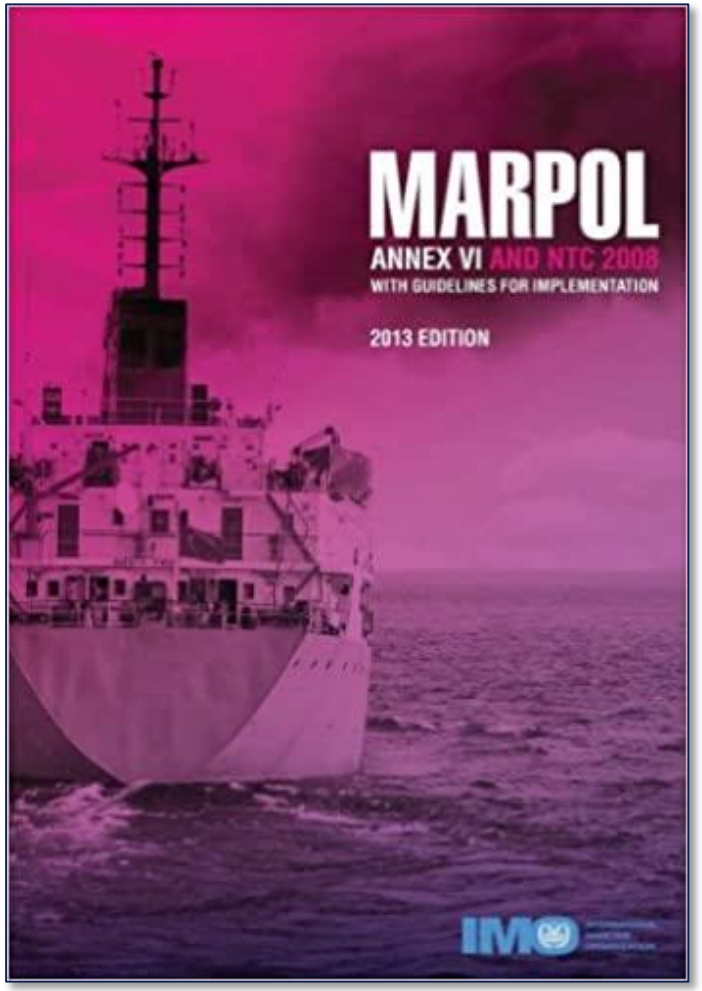
Are Biofuels considered in MARPOL Annex VI?

MARPOL Annex VI Regulation 18:

Fuel oil for combustion purposes delivered to and used on board ships to which this Annex applies shall meet the following requirements:

- The fuel oil shall be blends of hydrocarbons **derived from petroleum refining**
- fuel oil for combustion purposes derived by methods **other than petroleum refining** shall **not cause an engine to exceed the applicable NO_x emission limits.**

Bio fuels may have high Oxygen content (>10%), causing higher NOx emissions than conventional Diesel.



Testing with Biofuels

- Tests with Bio Fuels needed to fulfil Reg. 18 of MARPOL Annex VI (“shall not cause an engine to exceed the applicable NOx emission limits”).

- **Methods** to be applied for testing are **not clearly defined**
  - In case no alterations to engines are applied, DNV GL accepts “simplified measurement method” of NTC2008.

- Exemption by flag following Regulation 3 of MARPOL Annex VI “Trials for Ship Emission Reduction and Control Technology Research”.
  - Exemptions for the testing of the biofuels can be granted up to 18 months for smaller engines, up to five years for larger engines with cylinder displacements over 30 litres.

- Engine manufacturer has to state that Bio fuels can be used in the engine in order to prevent damages (viscosity, aging…).

- Letter of exemption needed by flag referring to
  - Test results
  - Specification of Biofuel used
  - Referring to alternative method for Bunker Delivery Note (BDN)

Properties and regulatory framework: Status

Working Group 7 “Fuels”

Subgroup Biofuels started

ISO 8217

Subgroup Biofuels started

Isolated discussions started

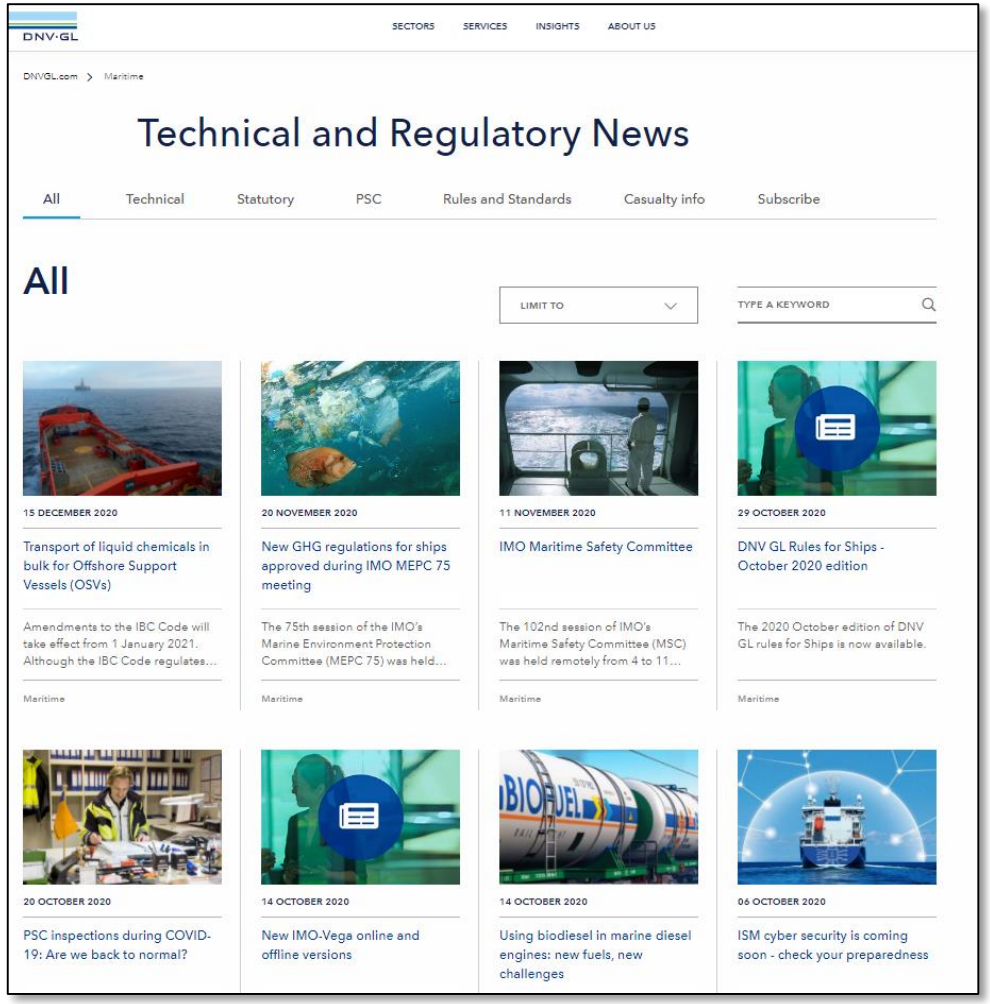
Bio Fuels:
Safety Aspects

Safety Aspects with Biofuels

- **Microbial growth**
  - leads to excessive formation of sludge, clogged filters and piping. Frequent draining of tanks and the application of biocide in the fuel may reduce or mitigate microbial growth.
- **Oxygen degradation**
  - Biodiesel can degrade over time, forming contaminants of polymers, and other insoluble
  - Deposits in piping and engines
  - Increased fuel acidity can result in corrosion in the fuel system and accumulation of deposits in pumps and injectors
  - Recommended not to bunker the fuel for long-term storage before use
- **Low temperature**
  - Biodiesels have a higher cloud point than diesel
  - Poor flow properties and the clogging of filters at lower temperatures
- **Corrosion and degeneration**
  - Most critical for biodiesel in higher concentration (B80-B100)
  - Some types of hoses and gaskets could degrade
  - Possible degeneration of rubber sealings, gaskets and hoses
- **Conversion/Fuel change over**
  - Biodiesel has shown to have a high solvent property
  - When switching from diesel to biofuel it is expected that deposits in the fuel system will be flushed and fuel filters might clog

Bio Fuels:
Outlook

DNV GL Technical and Regulatory News



https://www.dnv.com/news/using-biodiesel-in-marine-diesel-engines-new-fuels-new-challenges-186705

Main take-aways

- **The term *biofuel* is very generic, and sometimes misleading**
- **Biofuel-production will likely see strong growth in the future**
  - Road-transportation will likely be the main market for biofuels in the short-to-medium term, however, a growing share may be consumed by shipping
- **Source of biomass is a major determinant of biofuel lifecycle GHG emissions**
  - In general, the GHG-reduction potential of conventional biofuels is lower than for advanced biofuels
- **Over the next decade the shipping industry needs to start rolling out the new generation of carbon-neutral ships**
  - It is hard to identify clear winners among the many different fuel options across all scenarios, but DNV GL's analysis found that e-ammonia, blue ammonia and bio-methanol may be the most promising carbon-neutral fuels in the long run
- **To drive the development of new fuels and technologies, a clear and robust regulatory framework must be in place to**
  - ensure global availability of large volumes of carbon-neutral fuels
  - to enable their safe use
  - to incentivize their uptake while retaining a level playing field

Thank you!

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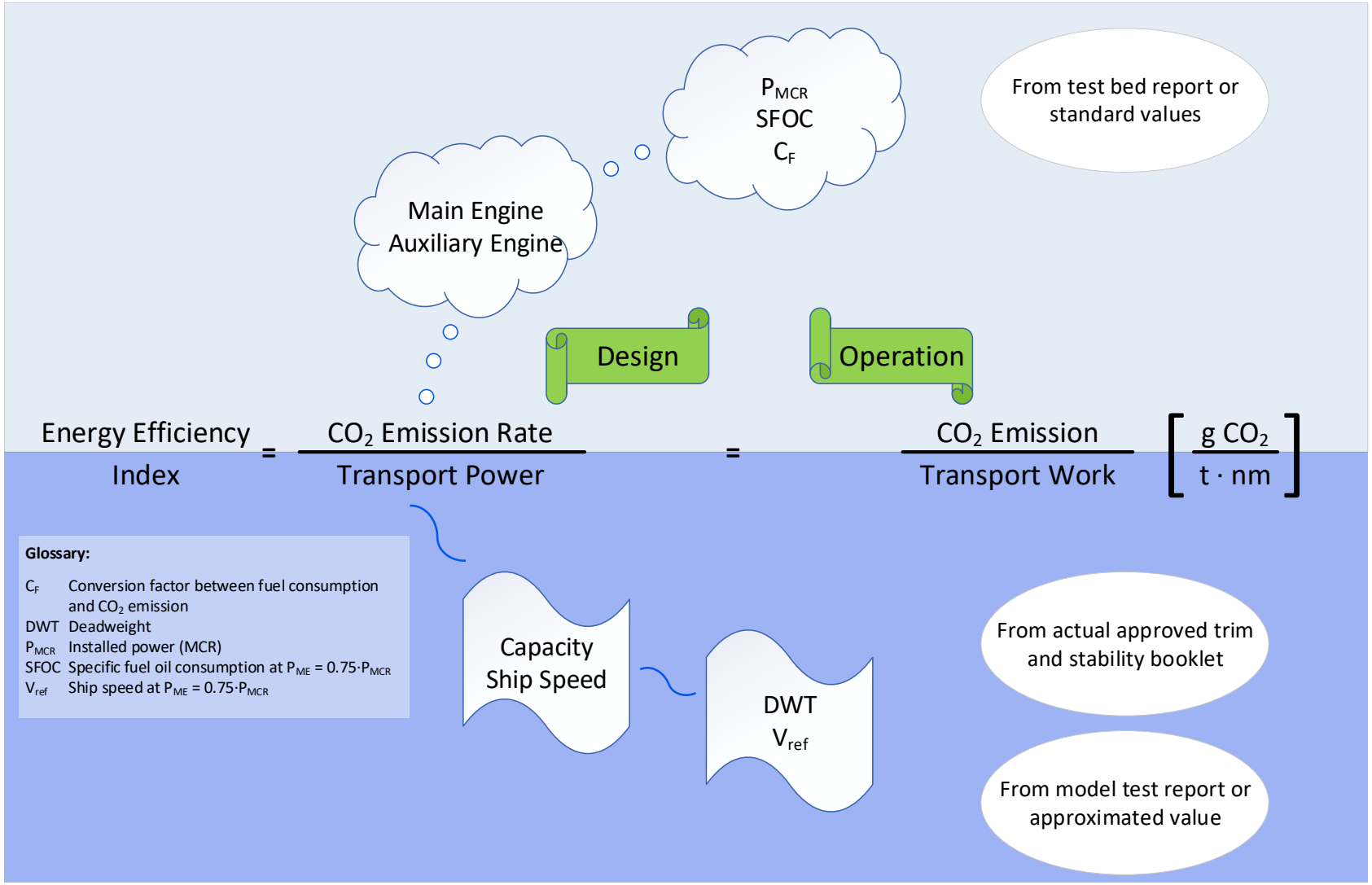
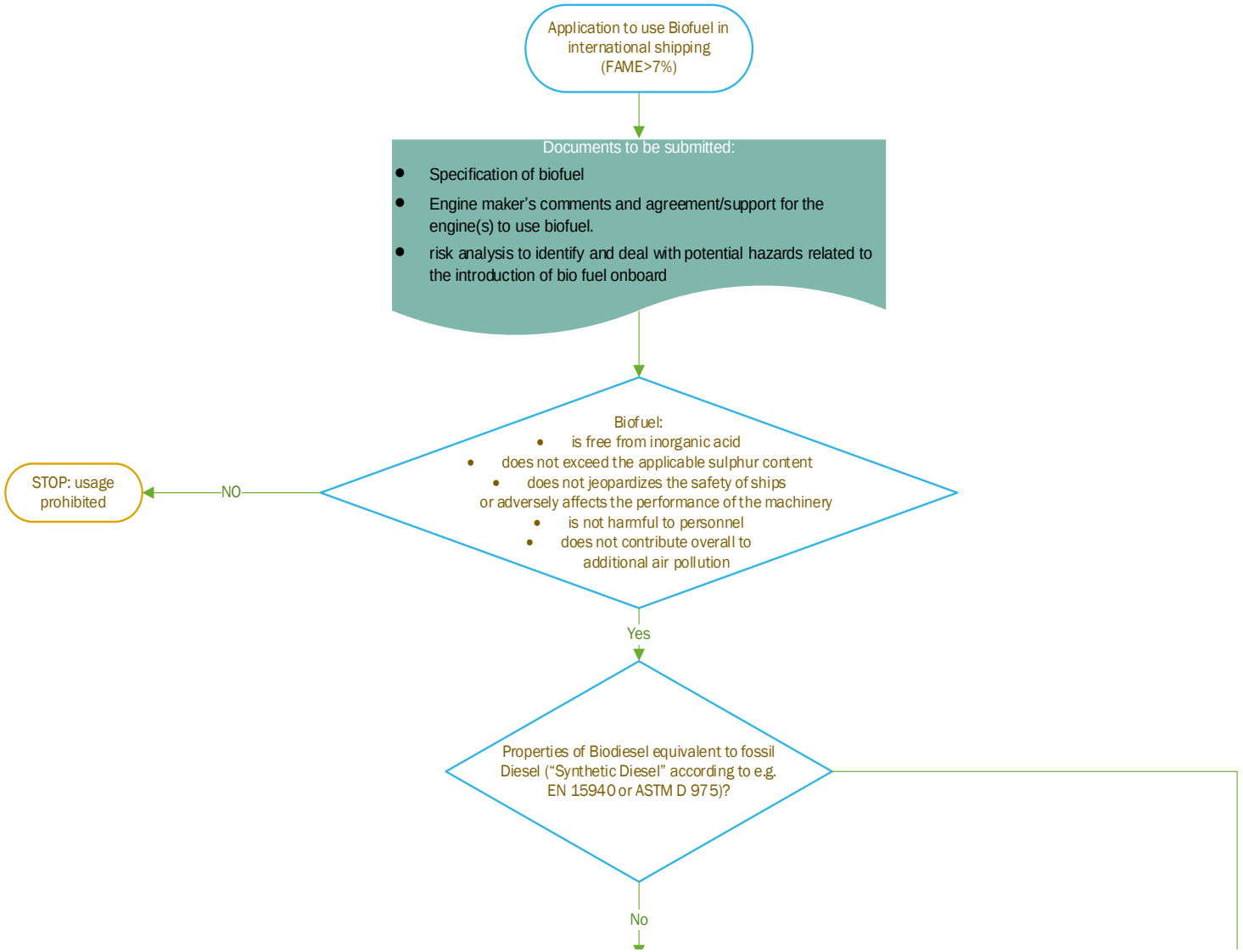
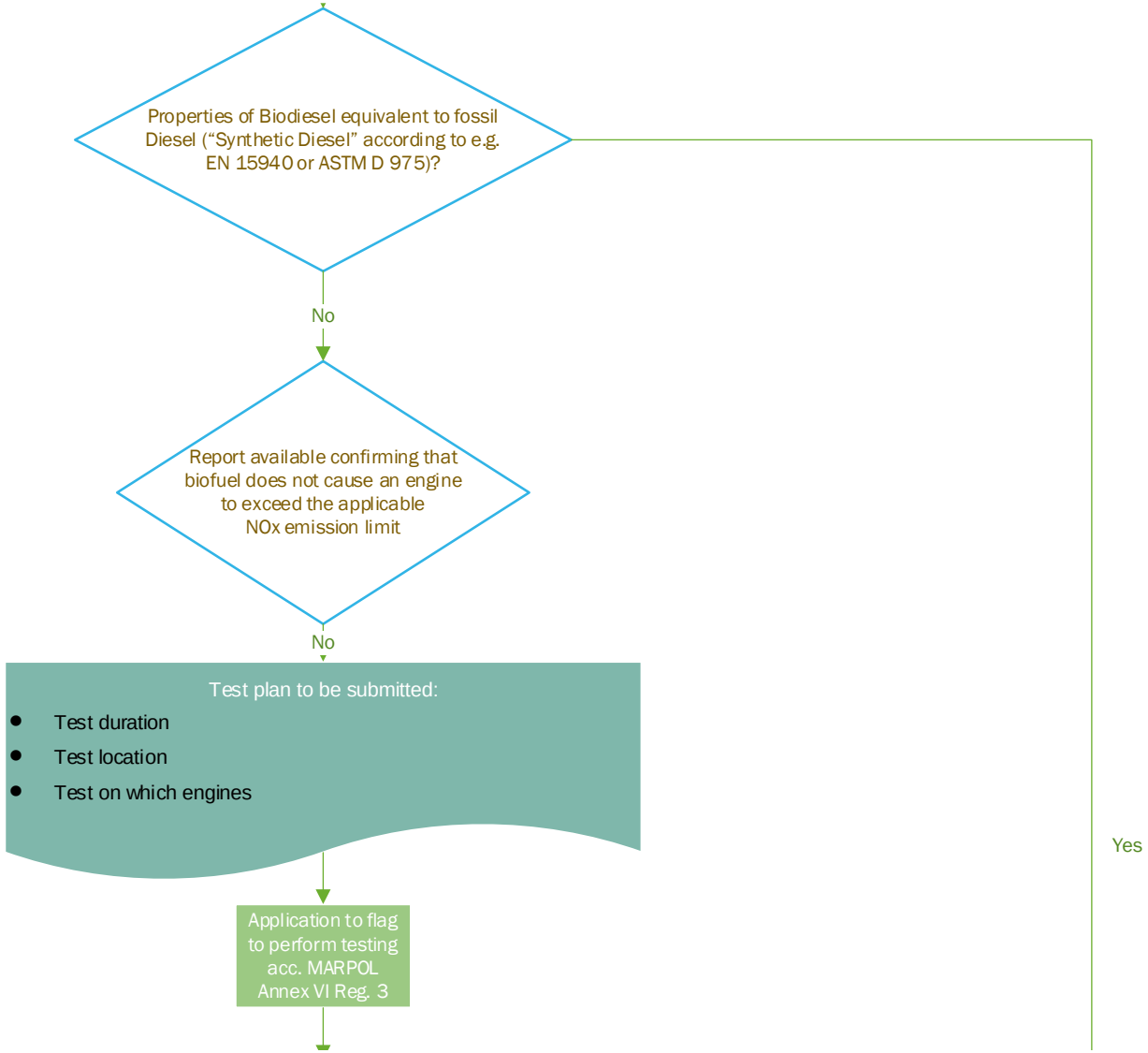
Basic concept of EEXI and CII



Flowchart: Acceptance of usage of Biofuels (1)



Flowchart: Acceptance of usage of Biofuels (2)



Flowchart: Acceptance of usage of Biofuels (3)