



**GHENT
UNIVERSITY**

LIPID BASED BIOFUEL PERFORMANCE FROM LARGE

SCALE ENGINES OPERATIONS

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OBJECTIVE

This presentation will provide the use of waste animal fats, oils and UCO's for use of marine biofuels.

Emphasis will concentrate on the special aspects of refining of the raw materials and the use of the drop-in fuels in large scale marine diesel engines.

CONTENT

1. General information:
 - History
 - Lipids as biofuel
 - Pathways for production of biofuels
2. Use of fats/oils as biofuel at Biopower
3. Refining of lipids
4. Advantage of using lipids in marine biofuels
5. Generation of power in marine diesel engines
6. Conclusion

HISTORY: USE OF FATS/OILS AS BIOFUELS

- Rudolf Diesel 1912
- The vegetable oils make it certain that motor-power can still be produced from the heat of the sun, which is always available for agricultural purposes, even when all our natural stores of solid and liquid fuels are exhausted

HISTORY: USE OF FATS/OILS AS BIOFUELS

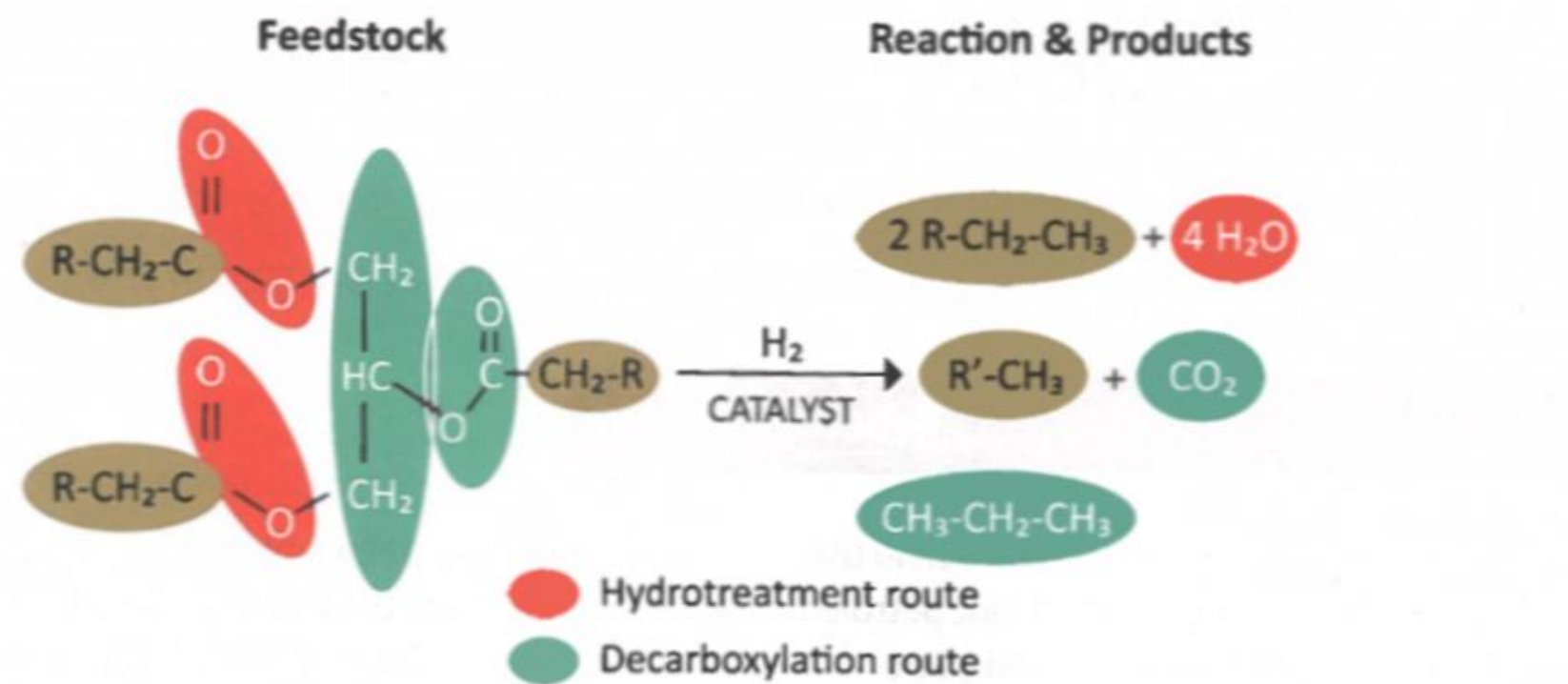
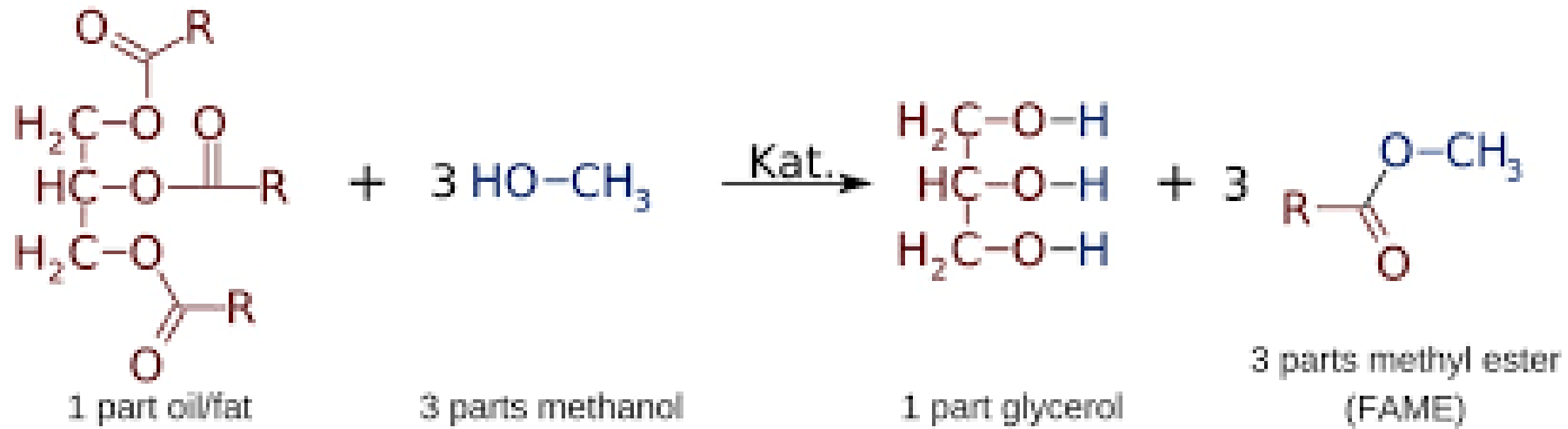
- 1900-1940: use of vegetable oils
 - 1900: Diesel: arachide oil
 - Africa: arachide, palm oil
 - France, Belgium
- 1937: first use of “biodiesel”
 - Belgian Congo: Chavanne: use of ethyl esters of palm oil (acid catalysed)
 - Belg Pat , 422.877
- 1938: First in EU: Bus: Leuven – Brussels
- 1942: Bull. Agric Congo Belge: 33, 3 (1942)
 - POE: CN83

HISTORY: USE OF FATS/OILS AS BIOFUELS

First experiments:

- Blending vegetable oils with diesel fuel (DF) for agriculture.
 - ➔ disadvantage: formation of deposits
- Strategy:
 - Adapting engine to the fuel: vegetable oil engines ➔ stationary engines
 - Adapting the fuel to the engine: **biodiesel**

HISTORY: USE OF FATS/OILS AS BIOFUELS



Triglyceride

$\text{R} = \text{C}_x\text{H}_y$

- Straight hc chain, R typically $\text{C}_{12}\dots\text{C}_{20}$
- number of double bonds depends on feedstock type

HVO diesel fuel

$\text{C}_n\text{H}_{2n+2}$

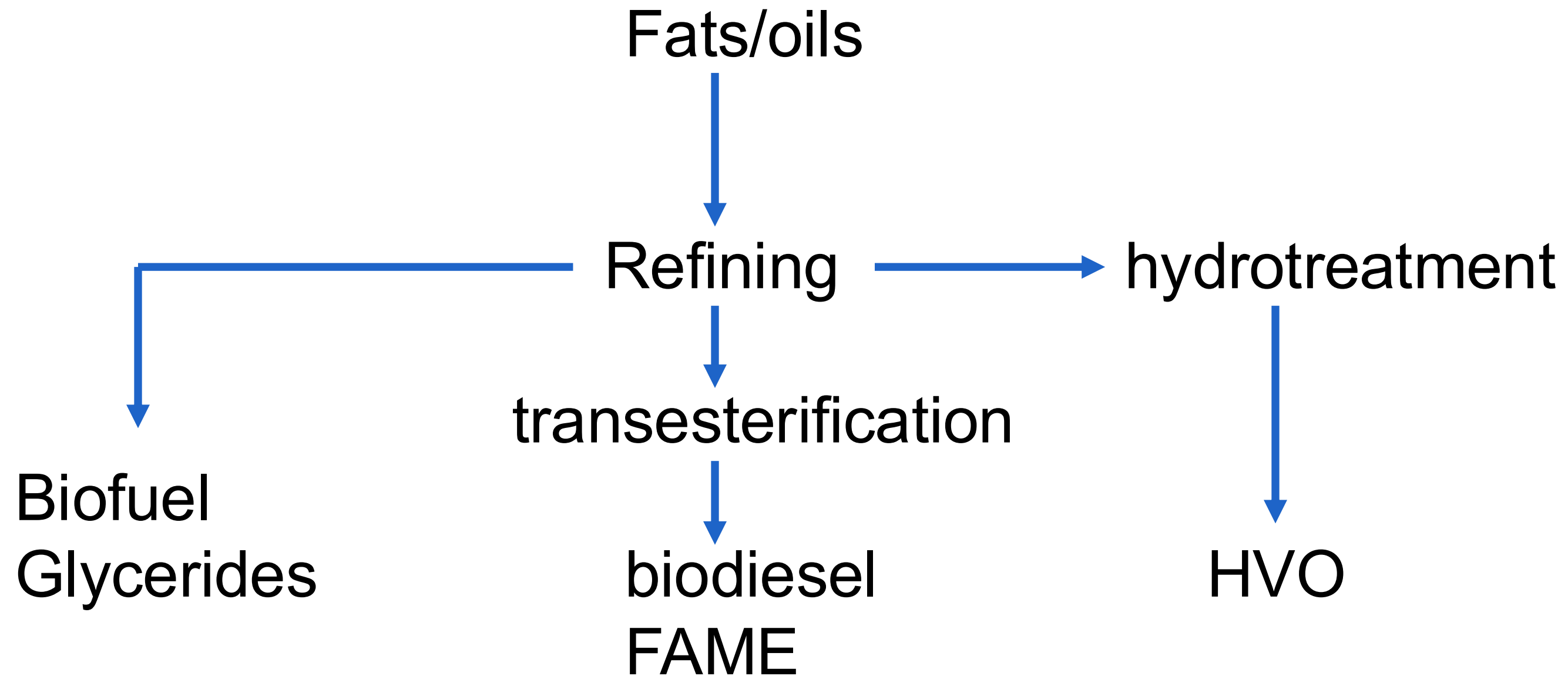
- fully saturated paraffinic hydrocarbon

WHY ARE LIPIDS AND DERIVATIVES SUITABLE AS FUEL

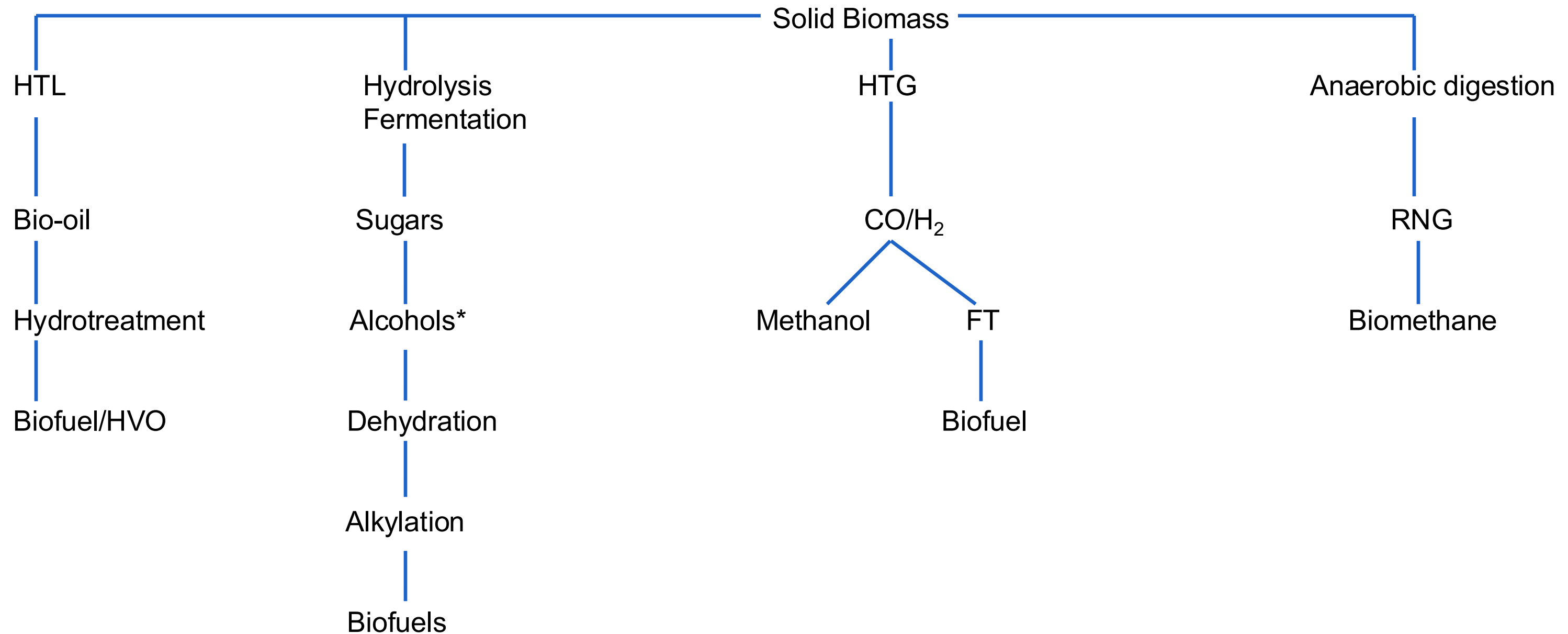
TAG ~ FAME

- Identical chemical structure and reactivity
- Same energy content 40000 kJ/kg
- Comparable density, cloud point
- Cetane number: TAG: 40; FAME: 45
- Different viscosity: TAG: 40 mm²/s; FAME: 4.5 mm²/s
- TAG: high flash point/smoke point

PATHWAYS FOR THE PRODUCTION OF MARINE BIOFUELS



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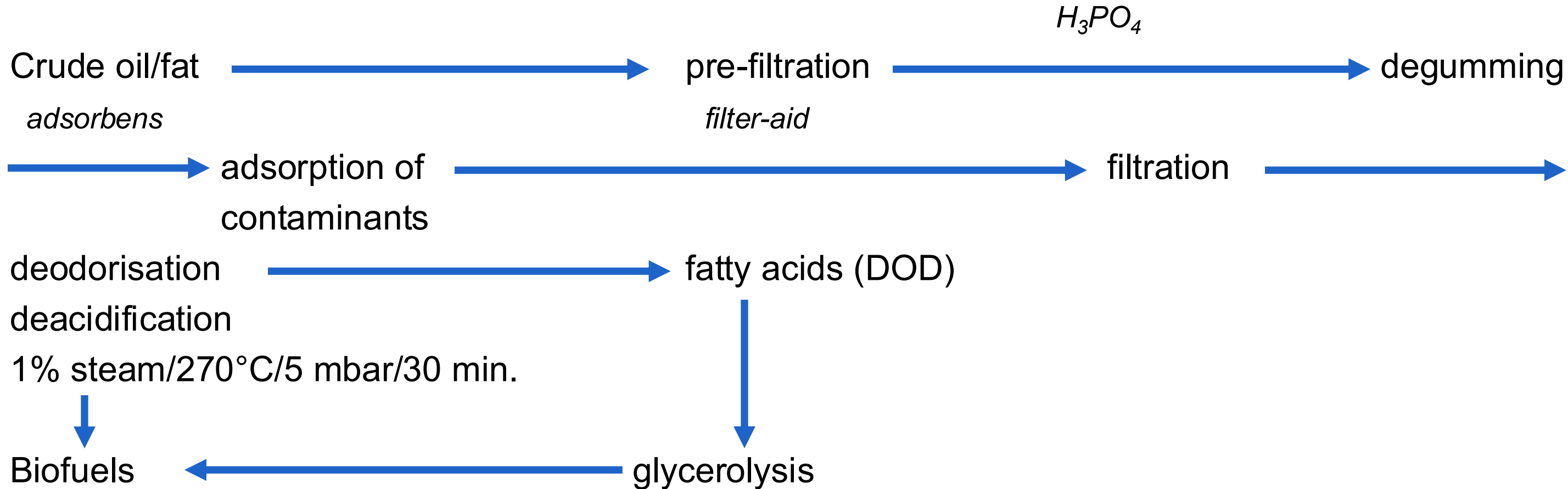


* In situ biofuel

BIOPOWER, OSTEND BELGIUM

- 2003: Electrawinds: refining of crude oils/fats (mainly animal fat cat.1) and generation of electricity (CHP)
- 2010: Production of biodiesel from animal fat cat.1 at Sas van Gent, the Netherlands
- 2015: Biopower: electricity generation
- 2023: Refining of animal fat/UCO's for biodiesel, HVO/SAF

REFINING TECHNOLOGY OF CRUDE ANIMAL FATS AND UCO'S



Degumming: removal: gums, proteins, phospholipids
 Adsorption: removal: fosfolipids, metals
 Deacidification: removal fatty acids

PRODUCTION OF BIOFUELS FOR MARINE DIESELS AT BIOPOWER

Glycerolysis: Production of synoils: esterification of fatty acids with glycerol at
220°C/100mbar/6 hours

Composition of synoil: - TAG: 35%
 - DAG: 50%
 - MAG: 15%

Animal fat for diesel engines: - 75% refined animal fat
 - 25% synoil

Yield: 93-95%; fat loss: 3-5%

QUALITY PARAMETERS OF BIOFUEL FROM ANIMAL FAT CAT. 1

	MAN	Crude	Refined
Density 15°C	900-930	900	850-870
Flash point	>60	>60	>60
Caloric value (mJ/kg)	>35	35-38	37-39
Viscosity 25°C (CST)	40	40-45	40
Cetane number	40-45	35-39	36-39
Sediment (ppm)	<200	2000	400
Water (%)	<0,5	0,5-0,9	0,05-0,1
TAN (mg KOH/g)	<5	30-60	4-5
Total metals (ppm)	24	400-1000	20-30
Phosphorous (ppm)	<15	200-400	5-10
N (ppm)	-	50-400	800-2000
S (ppm)	200	100-300	80-120
Soap (ppm)	-	2000-4000	500-1000

PRODUCTION OF MARINE BIOFUELS FROM UCO's

	Crude UCO	Refined UCO
Fatty acids (%)	10,17	0,5 – 1
Water (ppm)	4000	500
Ca (ppm)	3	0
Fe (ppm)	4	1
K (ppm)	5	0
Na (ppm)	11	4
P (ppm)	20	4
Si (ppm)	7	5
N (ppm)	150	110
S (ppm)	< 10	<10

PRODUCT SPECIFICATIONS OF MARINE BIO FUELS

Material	FFA %	P ppm	Metals ppm	N ppm	S ppm	Cl ppm	PE ppm
Edible oils	<5	20-300	100-400	30-500	2-30	<5	-
UCO	1-15	<50	<100	5-50	5-200	20-100	0-500
Animal fats	2-40	50-1500	200-2000	50-2000	20-300	50-500	0-1000
Deo dist.	50-90	<5	<20	50-1000	10-500	25-50	-
Acid oils	50-70	100-1000	100-2000	50-500	20-200	5-25	-
Animal fat cat. 1	10-50	100-1000	100-1000	200-2000	20-500	50-500	0-2000

QUALITY PARAMETERS OF REND AND SAF FEEDSTOCKS

FEEDSTOCKS	CONCENTRATION
FFA %	5-95
Moisture ppm	500-750
Total contamination ppm	500
P ppm	1-5
Metals ppm	5-25
N ppm	10-400
S ppm	20-400
Halogens ppm	0-10
PE ppm	0-50

PRODUCTION OF MARINE BIOFUELS FROM LIPIDS AND BIOMASS

- No conversion process to produce the suitable crude biofuel
- The production process: conventional refining step as edible oil processing
- After refining: no need for additional processing or chemical transformations
- Suitable density, viscosity and flash point
- Low oxygen content: highest energy content in bio resources (except biomethane)
- High solubility in diesel and heavy fuel oil
- Economics: cost crude lipids (600-1000\$/ton + 15% refining costs)

REFINED LIPIDS AS DROP-IN-FUEL IN HEAVY FUEL OIL HFO

- HFO: High Carbon hydrocarbones (C30-C60): alkanes, cycloalkanes, aromatics, asphaltenes, NSOx compounds and organic metallic compounds
- HFO properties:
 - kinematic viscosity: 180 cST/50°C
 - density: 900 - max. 1010kg/ton/50°C
 - sulfur: max. 5%

Refined animal fat has higher standards for chemical composition, physical properties, environmental friendly and similar logistics for transportation and storage, and use in conventional marine diesel engines.

Easy blending with HFO and used as drop-in-fuel for power (propulsion) and electricity.

BIOPOWER: GENERATION OF POWER

- Storage capacity: 30.000 Ton
- Refining: 70.000 Ton/year – max. 250 Ton/day
- Diesel engines: MAN marine diesel engines
 - 2 MAN 48/60: 18V cylinder
 - 18.5 MW = 25135 pK
 - stirring speed: 514 RPM
 - 3750 l/hr = 90 Ton/day
 - 48.000 households
 - 2 MAN 32/40: 18V cylinder
 - 8.5 MW
 - 1800l/hr
- Generator: AMG 1120/ABB
- Recuperation of heat: Turbine:
 - 1: 1.5 MW (1 engine)
 - 1: 1.0 MW (2 engines)

BIOPOWER: GENERATION OF POWER

- Total power production: 74MW
- Equivalent for 20 windmills
- Power for 140.000 households
- Refined animal fat can be used as a biofuel in marine diesel engines without modification of the engine and operational conditions.



BIOPOWER: GENERATION OF POWER



Bovenzicht scheepsmotor

MOTOR

Afmetingen | 13,1 m x 4,7 m x 6,3 m (LxBxH)

Gewicht | 307.000 kg

Vermogen | 18.5 MW of 25.135 pK

Cilinderinhoud | 18 cilinders met 1050 kW per cilinder

Toerental | tot 514 toeren per minuut

Brandstofverbruik | 3750 kg/uur of ongeveer 90 ton/dag



De motorhal met motor (links) en generator (rechts)



PURIFICATION OF EXHAUST GASES

- SCR: Selective Catalytic NO_x Reduction

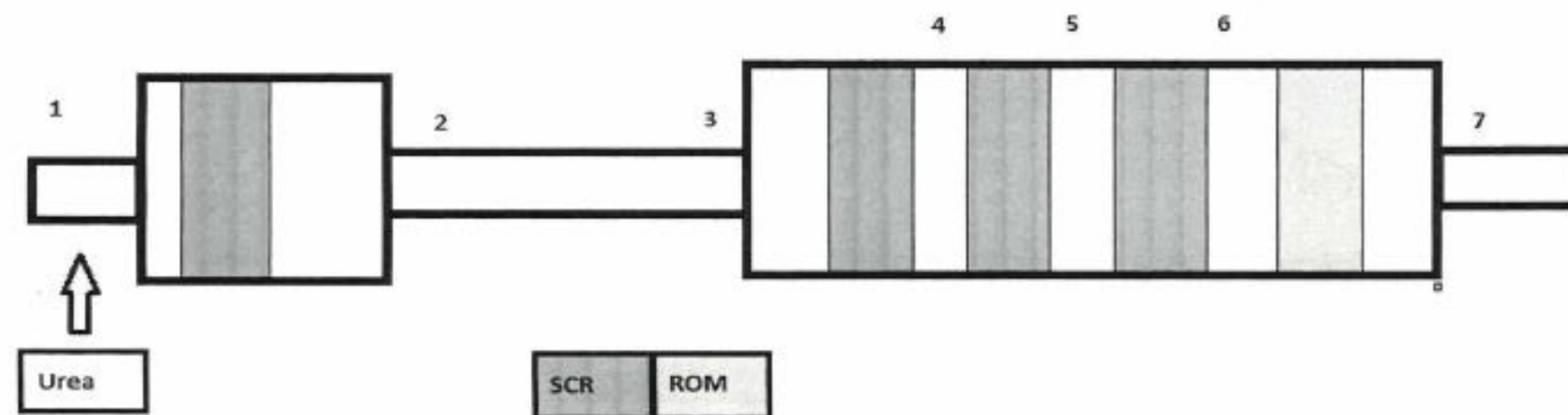


- OXI: Oxidising catalyst:



PURIFICATION OF EXHAUST GASES

Time	CO	N ₂ O	NO	NO ₂	NH ₃	O ₂	NO _X
	mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³	mg/Nm ³
1	27,15	1,37	1032,75	0	397,25	11,06	1761
2	58,6	1,38	331,63	0	113,92	11,53	596
3	68,18	0	376,11	0	97,59	12,2	595,29
4	109,3	1,99	111,92	0,93	26,59	12,14	178,8
5	98,62	1,75	46,11	0	19,53	12,05	74,2
6	/	/	/	/	/	/	/
7	31,11	13,89	102,99	0	5,27	11,84	164,53



CONCLUSION

Refined waste animal fat and UCO's are sustainable marine biofuels and can be used straight or in blends with HFO in marine diesel engines.

An unique refining technology has been developed and used for 20 years for the production of power.

The engines do not need additional transformation and operational conditions.

An up-to-date process for purification of the exhaust gases affords excellent environmental conditions.

In the future a blending with biofuels produced via biomass streams can enhance the development of sustainable zero-emission marine biofuels.

Thank you



for your attention!