

Biofuel Compatibility For Singapore Harbour Craft

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Project Introduction

- Aims to study the compatibility of “drop-in” biofuels for Singapore Harbour Craft decarbonization
- Three type of fuels are chosen: PME, UCOME and HVO.
- A passenger launch vessel with high speed diesel engine is chosen for the testing.
- Project duration is 18 months.

Main Considerations For Biofuel Adoption



Fuel Supply

- Availability
- Storage
- Blending
- Logistic
- Bunkering
- Economics

Engine

- Compatibility
- Power output and emission
- Maintenance
- Material compatibility

Environmental

- GHG
- Pollutant emission
- Fuel spill
- ...

Fuel Quality

- Fuel types
- Fuel standard
- Stability

Biofuel Production And Supply

Regional FAME Biodiesel Supply

- FAME is the major type of biofuel produced in SEA.

Year 2019	Indonesia (million m ³)	Thailand (million m ³)	Malaysia (million m ³)
Production	7.7	1.845	1.69
Export	1.270	0.021	0.345

(Source: United States Department of Agriculture)

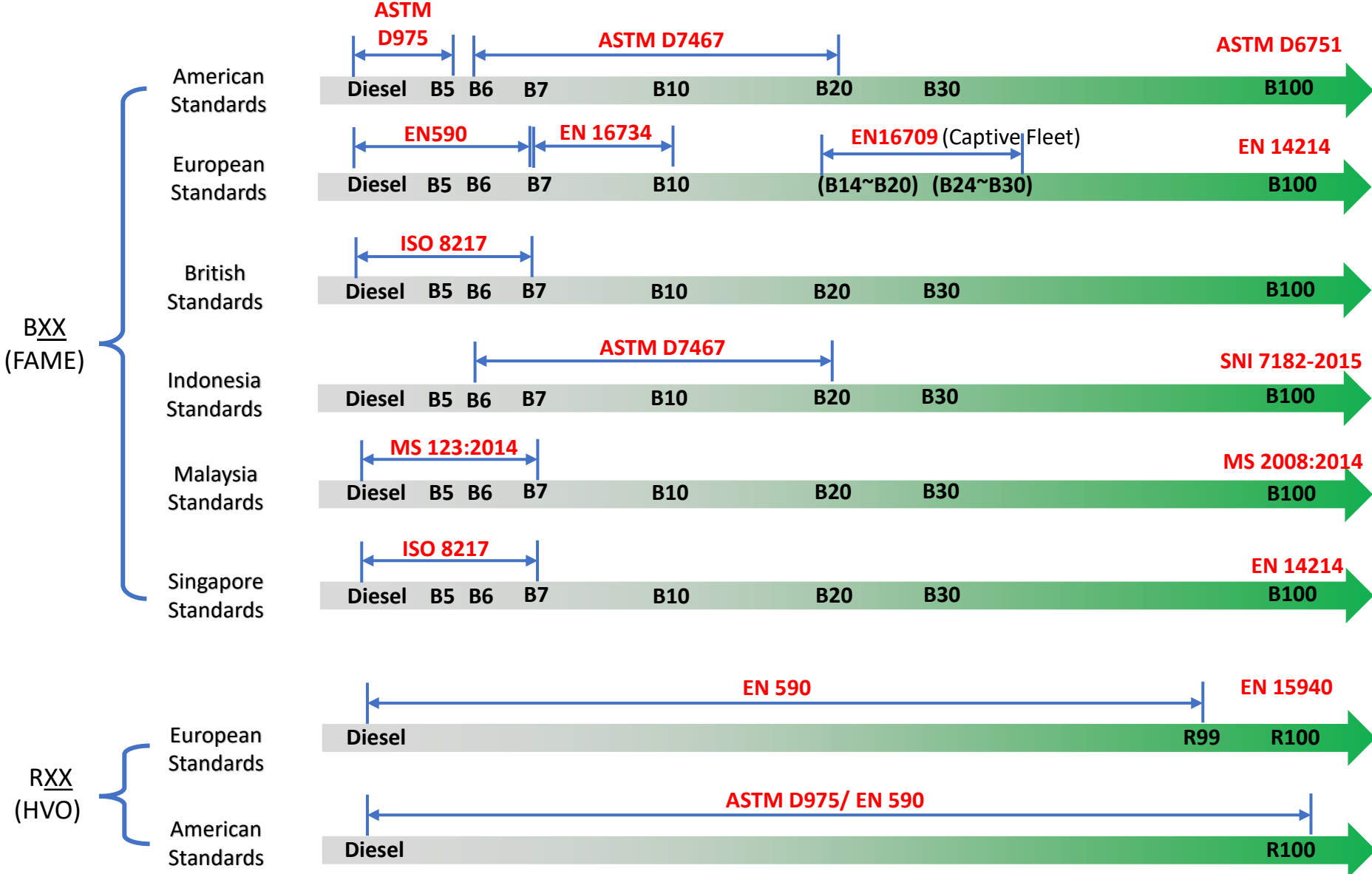
Global FAME and HVO Production

- HVO capacity rose 15% in 2020 while FAME rose slightly.
- Increase of HVO is due to the expansion of existing facilities and new production sites. (Source: REN21)

	FAME (million m ³)	HVO/HEFA (million m ³)
Production (2019)	46.5	6.5
Production (2020)	46.8	7.5
Leading production countries (2020)	Indonesia (17%) USA (14.4%) Brazil (13.7%) Germany (7.4%)	Finland Netherlands Singapore USA



Fuel Standard Involved



Fuel Stability

Parameters to check over time

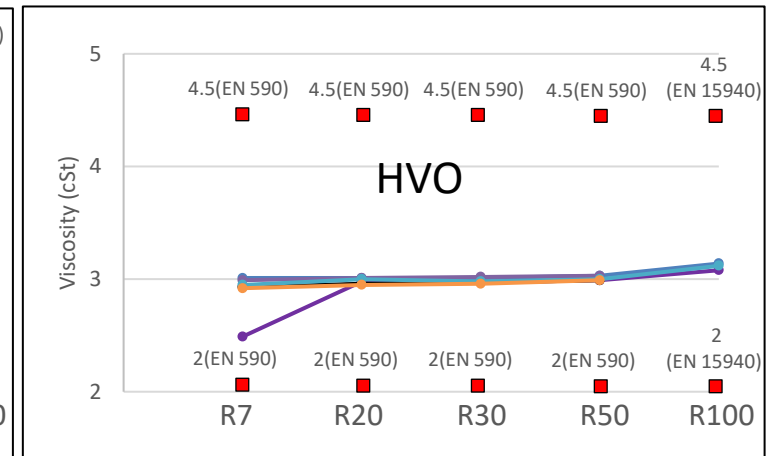
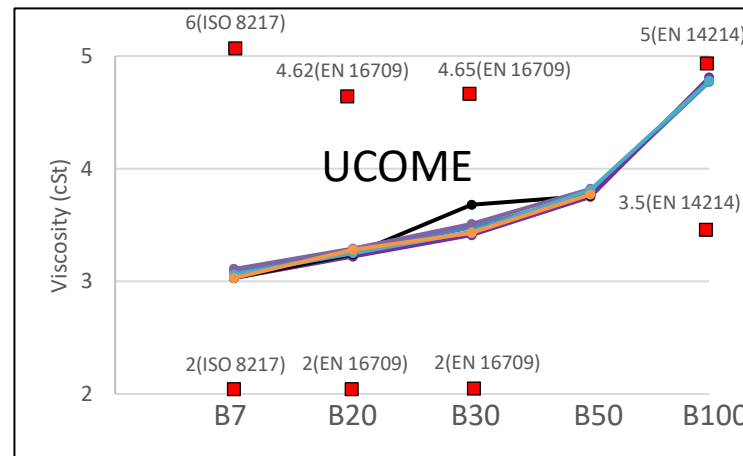
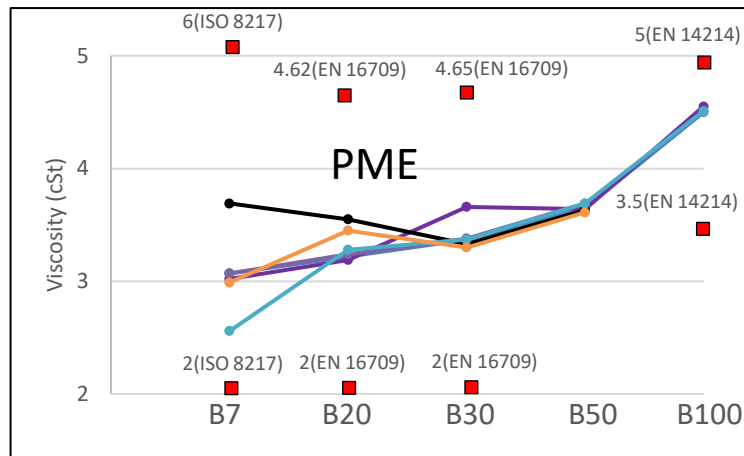
1. Viscosity
2. Water content
3. Acid value
4. Oxidation stability

By sediment

By induction period



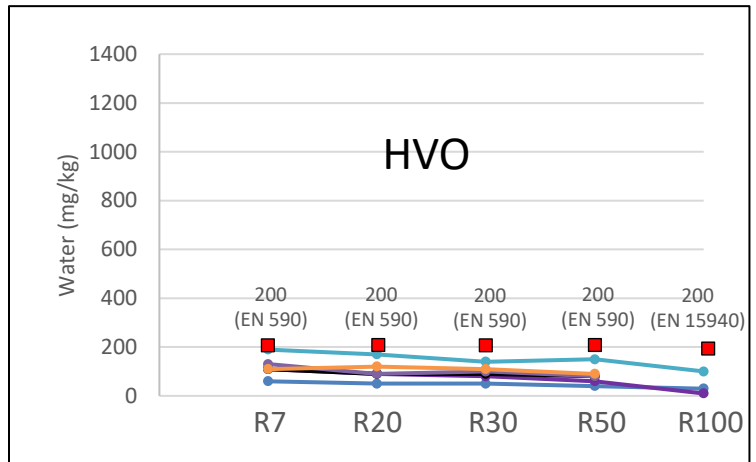
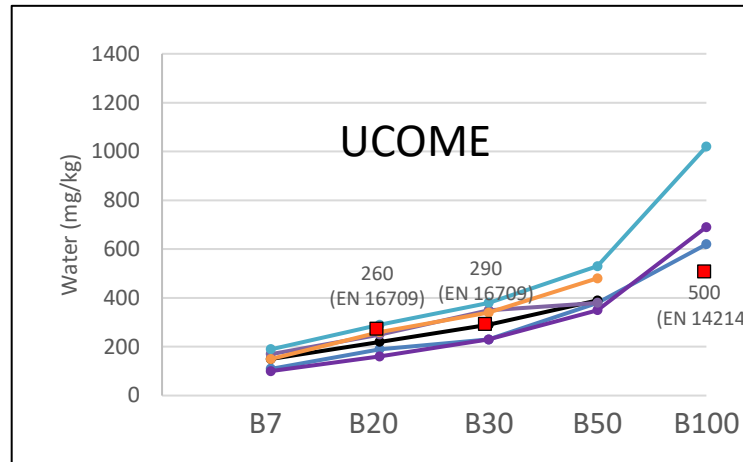
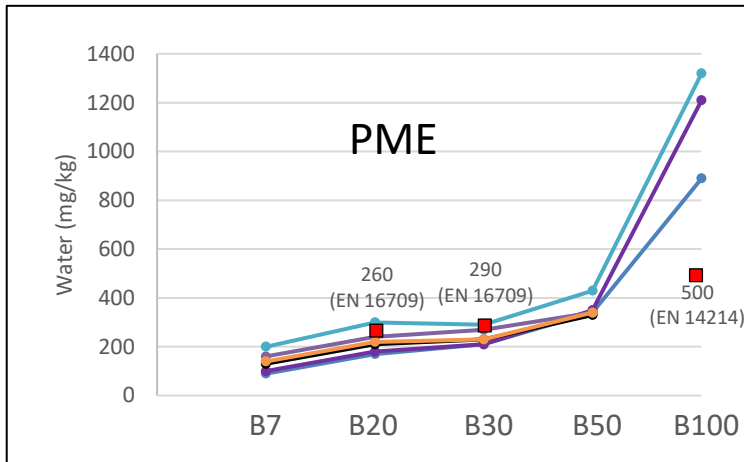
Viscosity: stays within range of available EN standards



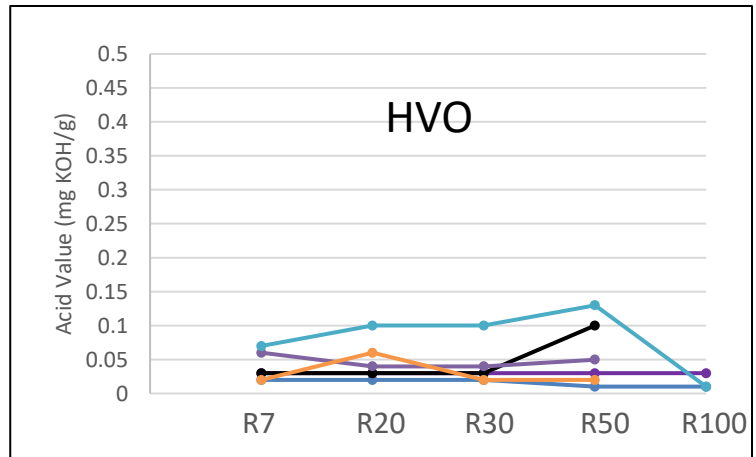
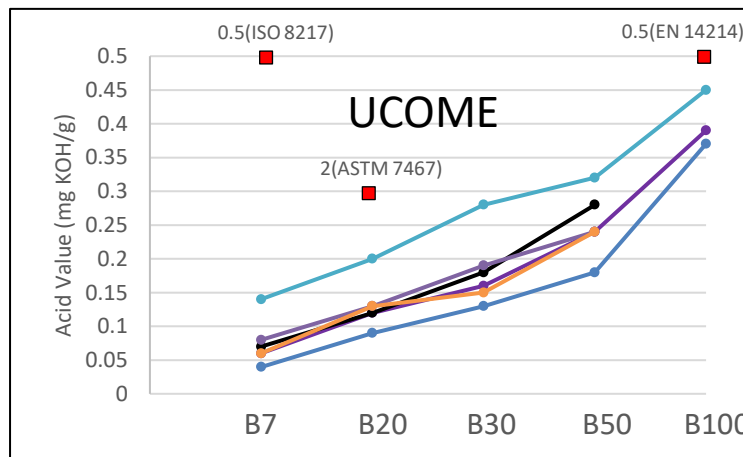
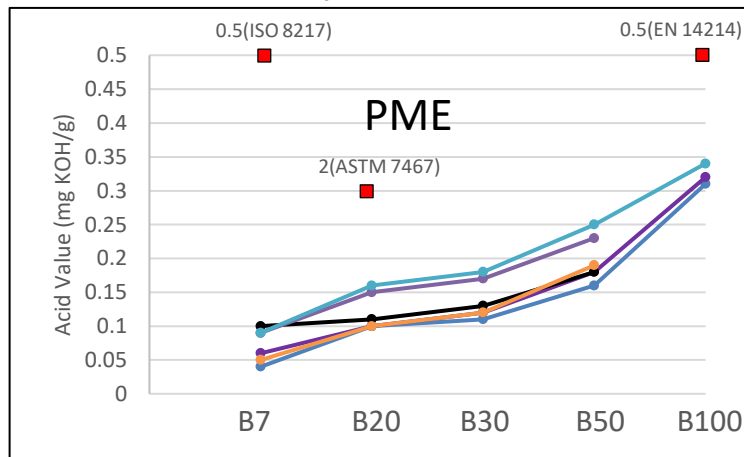
Week 0 Week 4 Week 8 Week 12 Week 16 Week 20

Fuel Stability

Water Content: stays within the range of EN standards after 4 months except for B100 (PME & UCOME), all HVO samples pass



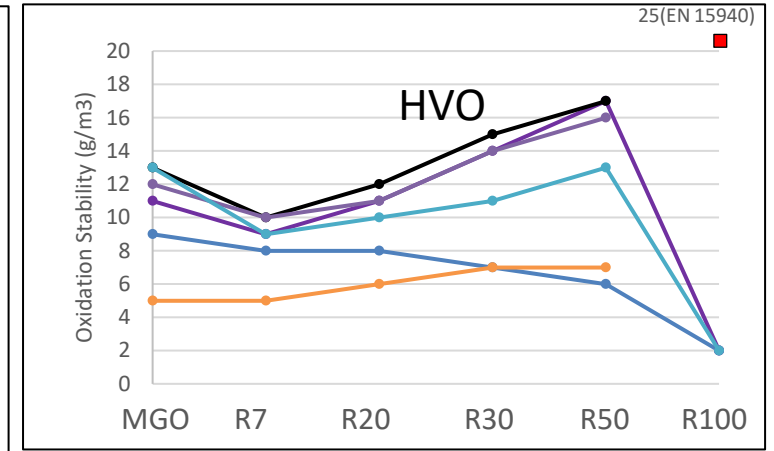
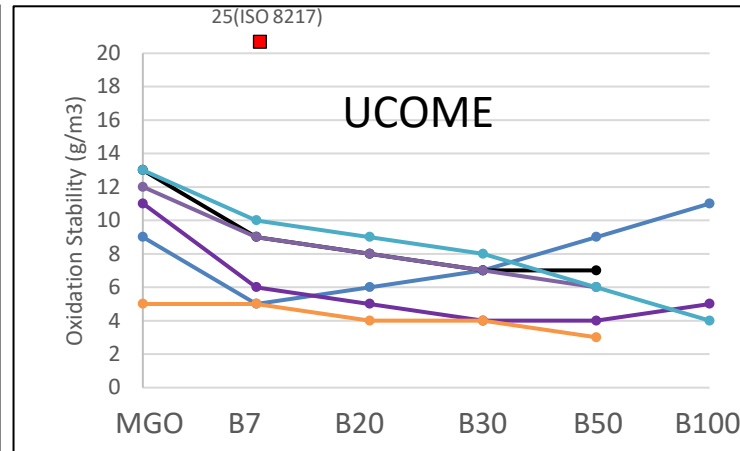
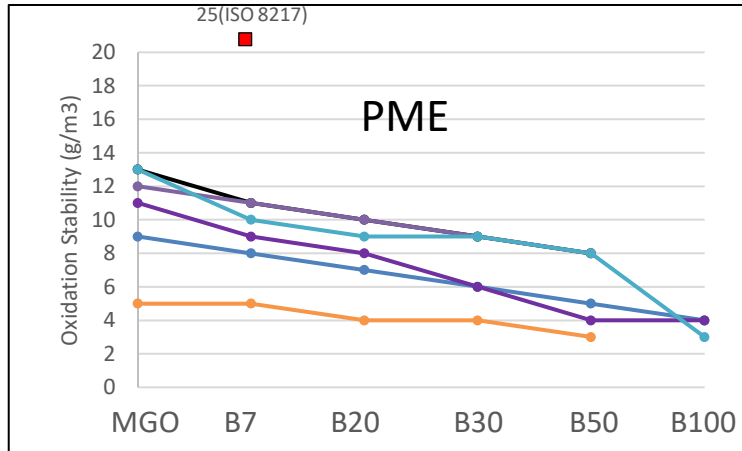
Acid Value: All stay within EN standards



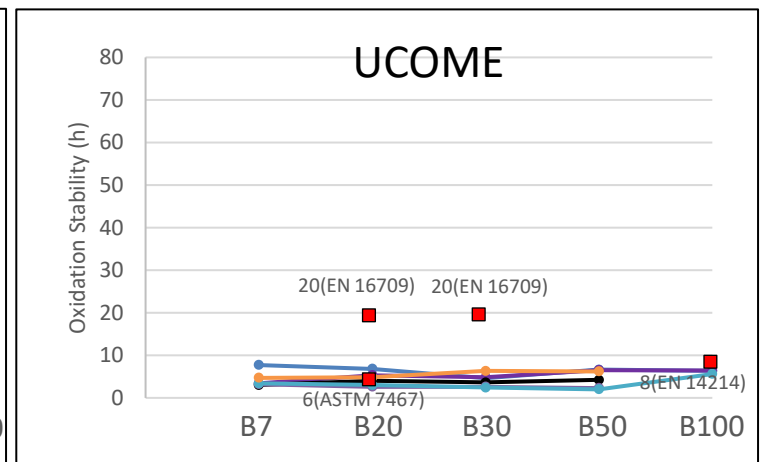
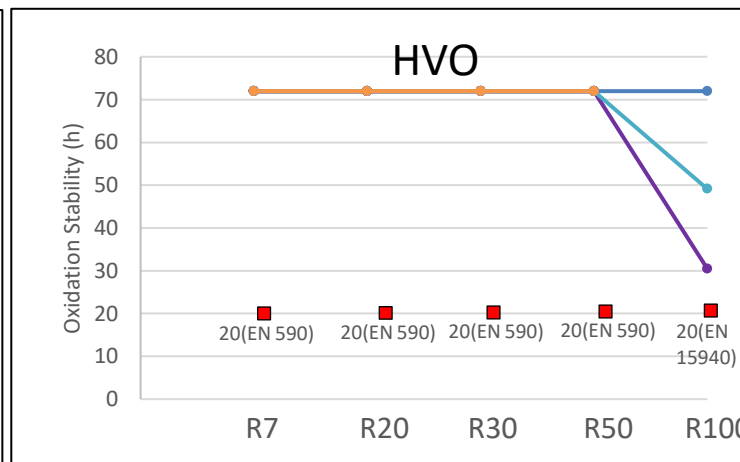
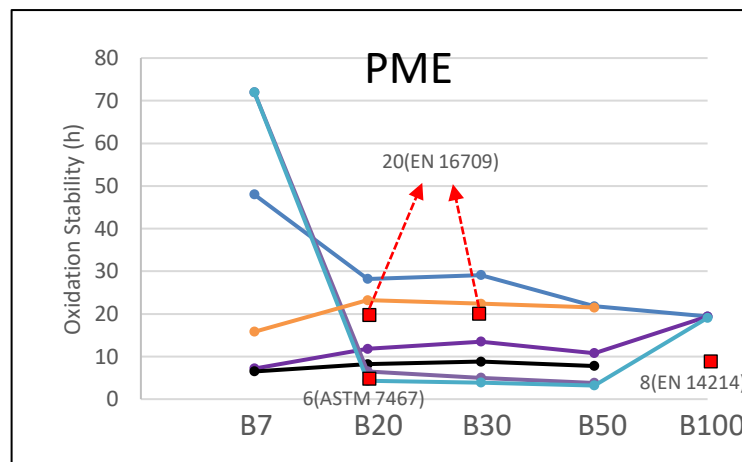
Legend: Week 0 (blue), Week 4 (purple), Week 8 (black), Week 12 (yellow), Week 16 (light blue), Week 20 (green)

Fuel Stability

Oxidation Stability (sediment): All stay with either ISO or EN standard limits



Oxidation Stability (induction period): PME blends allow decent storage time (8 weeks); UCOME blends stay within specs only when fresh; HVO stays fresh after 20 weeks.



Week 0 Week 4 Week 8 Week 12 Week 16 Week 20

Sea Trial Summary – Vessel Preparation



Vessel specification

- Type: Cargo launch (<12 pax)
- Engine: Dual Weichai WD series engine
- GT: 27 ton
- Net tonnage: 13 ton
- Dimensions (L x W x H): 13.5 m x 3.8 m x 2 m
- Draft: 1 m



Engine preparation

- New lube oil
- New gasket (NBR) for fuel filter
- New 316L SS fuel pipe
- New NBR and PVC fuel hose connection



Equipment installation

- Exhaust gas analyser (NO_x, SO₂, CO, CO₂)
- Pitot tube
- Ultrasonic flow meter
- Shaft power meter
- GPS
- Temperature & humidity logger



Bunkering arrangement

- Start @ Banyan shipyard
- Regular bunkering @ Penjuru Jetty
- Bunker quantity given by flow meter
- Bunker quantity verified by fuel level indicator

Sea Trial Summary – Test Routes

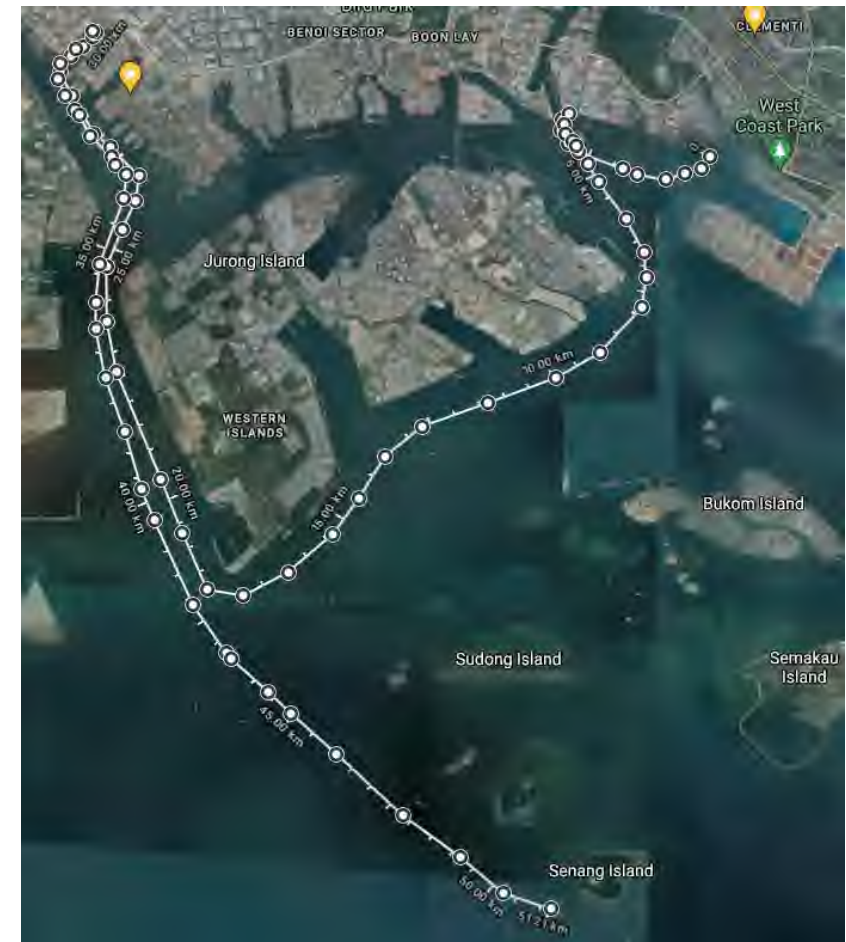
Chartered route for MGO baseline trial

Roundtrips from west coast floating buoy to southern end of Jurong Island

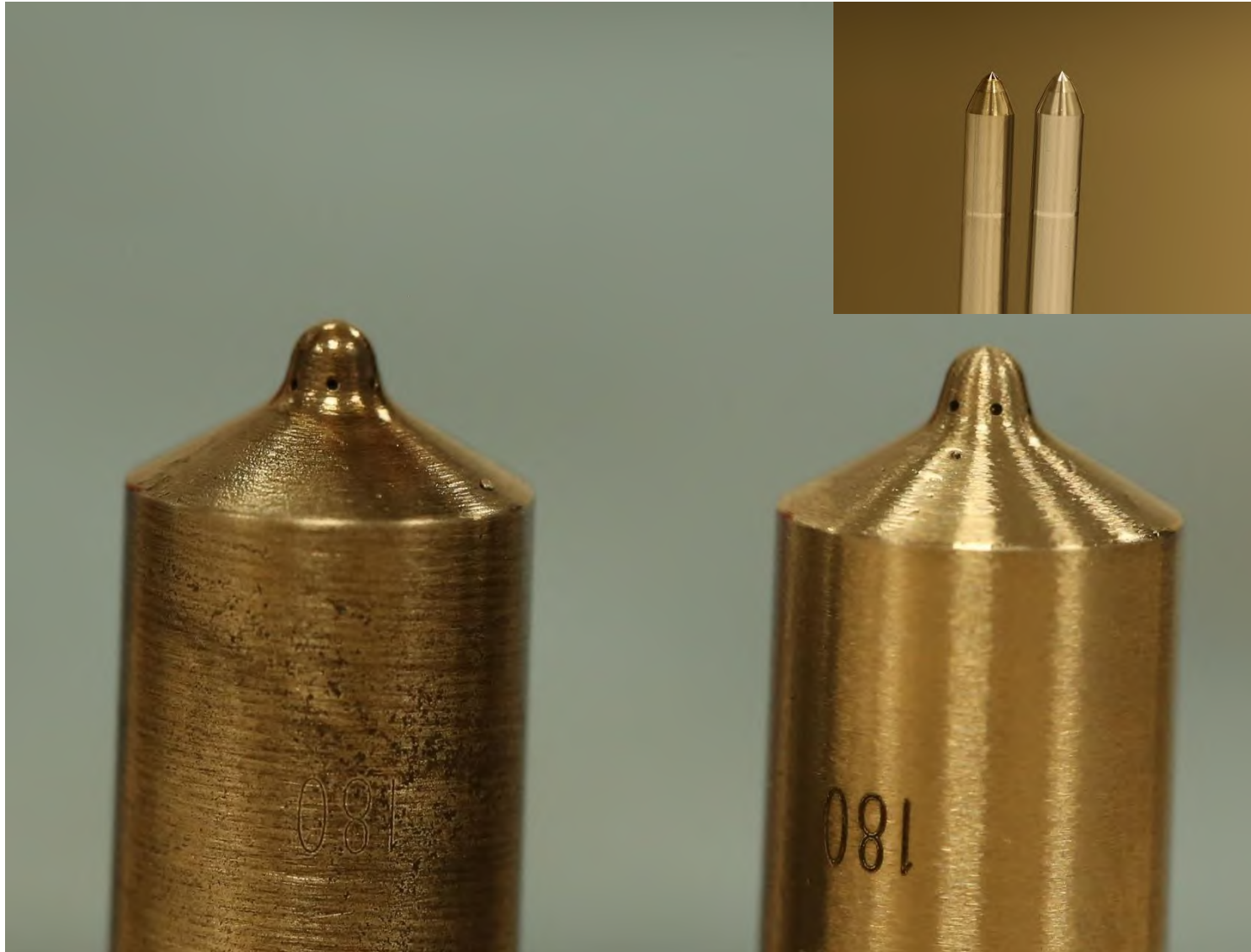


Chartered route for B30 trial

Roundtrips from Banyan shipyard to Sudong anchorage



Sea Trial Observations



Common materials	Use	Observation*
HDPE	Biofuel IBC tanks	No effect
PVC (transparent)	Fuel hose Level indicator	Hardened, non-brittle
NBR	Fuel hose Fuel filter gasket	Minor degradation of elasticity
316L stainless steel	Fuel pipe	No effect
GRE (glass reinforced epoxy)	Fuel tank Ship hull	No effect
Copper	Injector washer	No effect
Hardened steel	Fuel injector components	Normal wear & tear
Lube oil	Engine lubrication	Normal degradation

* Total biofuel (B30 PME) exposure time is 4 months

Sea Trial Observations



NO_x emission

Inconclusive yet, further investigation needed

Carbon monoxide

No change (74~98 ppm), same range as that of MGO

Exhaust gas temperature

Inconclusive, no difference from running with MGO

SO₂ emission

Below detection limit

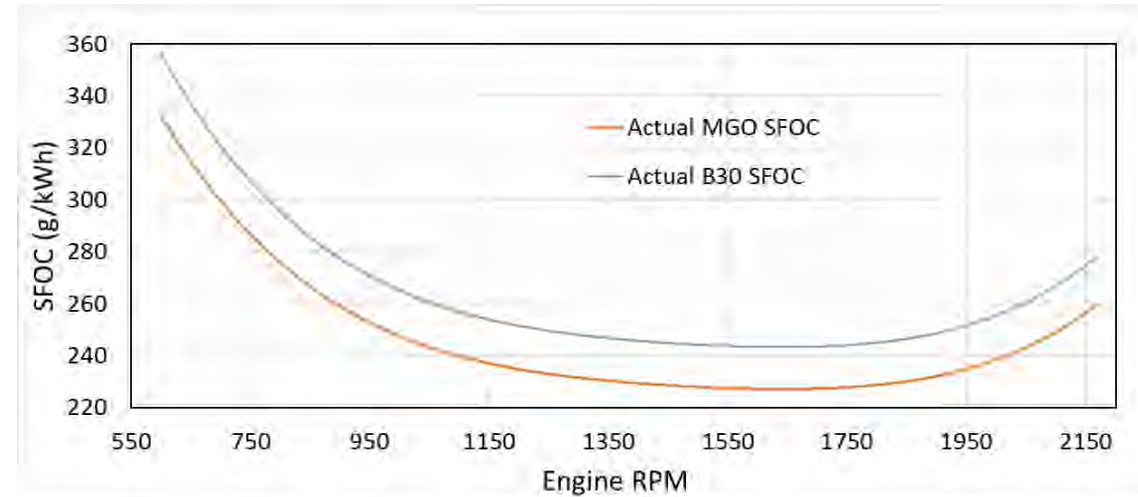
Maximum power

Only 1% loss of maximum engine rpm



Sea Trial Observations – Fuel Consumption & GHG Emission

- Data collected from 15 Apr to 22 Sep, 2021.
- B30 biodiesel exhibits 7% increase of SFOC than MGO.
- Possibility to reduce the fuel consumption gap if engine is designed for biofuel.



GHG emission of B30 PME and UCOME

Fuel	Well to tank (gCO ₂ e/MJ)	Increased SFOC (gCO ₂ e/MJ)	Tank to propeller (gCO ₂ e/MJ)	Well to propeller (gCO ₂ e/MJ)	GHG reduction LCA (%)	GHG reduction IPCC (%)
MGO	17.46 ^a	0	74.70 ^a	92.16	0	0
B30 (PME)	22.98 ^b	1.61	57.35	81.94	11.1	23.2
B30 (UCOME)	14.29 ^c	1.0	57.35	72.64	21.2	23.2

a: ICCT report, Jan 2020; b: Derived from supplier and MGO data; c: Derived from MESD result and MGO data

Compatibility To Singapore Harbour Craft



Work Flow

Extract vessel and engine population from registry



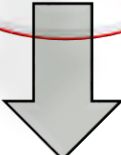
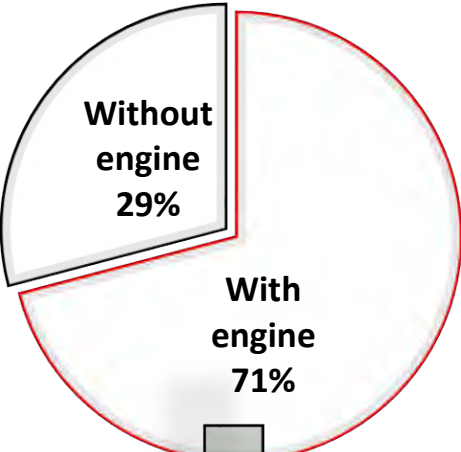
Survey and interview with engine OEMs



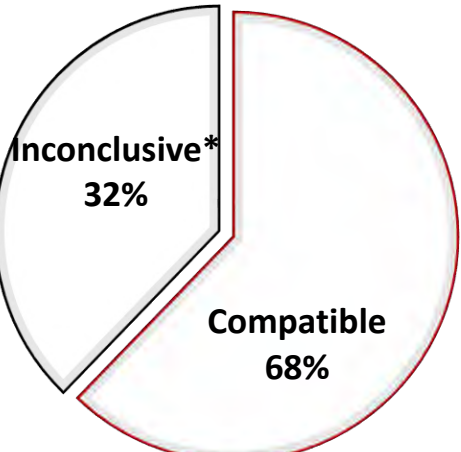
"Search match" to estimate compatible engines



Vessel Population



Biodiesel Compatibility



* Recommended to check with OEMs

Key Take Aways From Engine OEM Survey*

Blending Ratio

B20 and below

Overall good acceptance and support from existing and current engine models

B30 and above (up to B100)

Generally not recommended as “drop-in” fuel

Sea trials with gradual increase of blending are encouraged for higher blends

B100 ready engines are available for limited models or brand only

Fuel Quality & Standards

Quality

COA shall be adhered to

Biodiesel is more susceptible to elements and bacteria

Storage stability is critical

ISO 8217

Widely accepted

EN & ASTM

B100 as blending stock is generally acknowledged

Not ready for intermediate blends (from B7 to B99)

OEM’s own standard

Some OEMs do provide internal reference for biodiesel adoption

HVO related

Generally accepted as drop-in fuel

Engine Components & Maintenance

Components

MOC shall withstand the increased solvency and corrosion from biodiesel

Maintenance

Generally more frequent change of filter and lube oil

Fuel Consumption & Emission

SFOC

Minor effect for B20 and below
More pronounced effect from B30 and above

Emission

SO_x free
More NO_x (B30 and above)
Less PM

*Recommendations may differ for biofuels use in outdated or slow speed engines – do check with Engine OEMs

Moving Forward



- ✓ Test higher blends of FAME
 - PME and UCOME up to B50 and B100
 - GHG reduction potential
- ✓ Test HVO blends
 - Explore and gain operation experience
 - GHG reduction potential





Thank you

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