THE GREEN MARITIME FUTURE

Anders Valland

Research manager SINTEF Ocean

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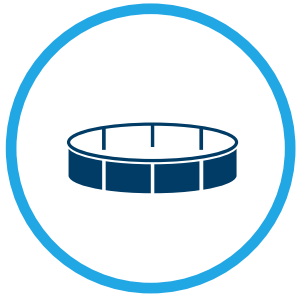
SINTEF Ocean – Research for ocean industries

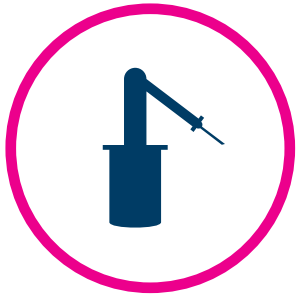


Aquaculture

Maritime

Bio marine resources

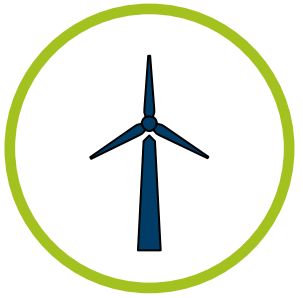
Oil and gas



Process industry

Environmental technology

Fisheries



Offshore wind

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SMART MARITIME

Norwegian Centre for improved energy efficiency and reduced harmful emissions

RESEARCH ORGANISATIONS

SINTEF

NTNU

DNV·GL

INDUSTRY STAKEHOLDERS

Norges Rederiforbund
Norwegian Shipowners' Association

Kystrederiene

Sjøfartsdirektoratet
Norwegian Maritime Authority

DESIGN, EQUIPMENT, SYSTEMS

ABB

JOTUN

HAVYARD

KONGSBERG

SIEMENS

VARD
a Fincantieri company

WÄRTSILÄ

Rolls-Royce

norwegian electric systems

SHIP OPERATORS

GRIEG STAR

ODFJELL

SOLVANG ASA

HÖEGH AUTOLINERS

Torvald Klaveness

KRISTIAN GERHARD JEBSEN SKIPSREDERI
PART OF THE KRISTIAN GERHARD JEBSEN GROUP

Wallenius Wilhelmsen Ocean

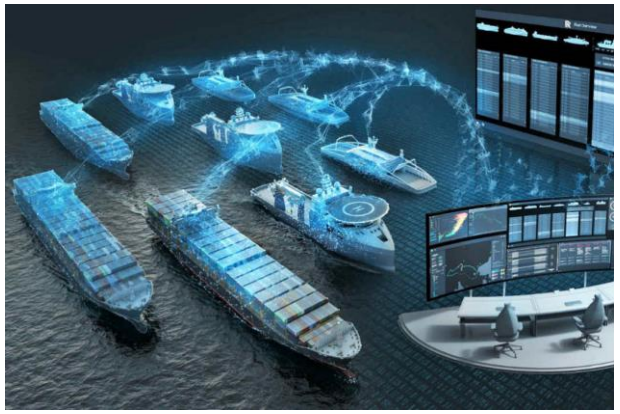
NTEF

Maritime zero emissions: Research needs

Fleet management and vessel utilization
external conditions, business models, human performance

Energy efficiency, choice of technology
Energy systems, CCS, hull, propeller, sail, foil

Fuels and energy carriers
Biogas, biodiesel, batteries, synthetic fuels



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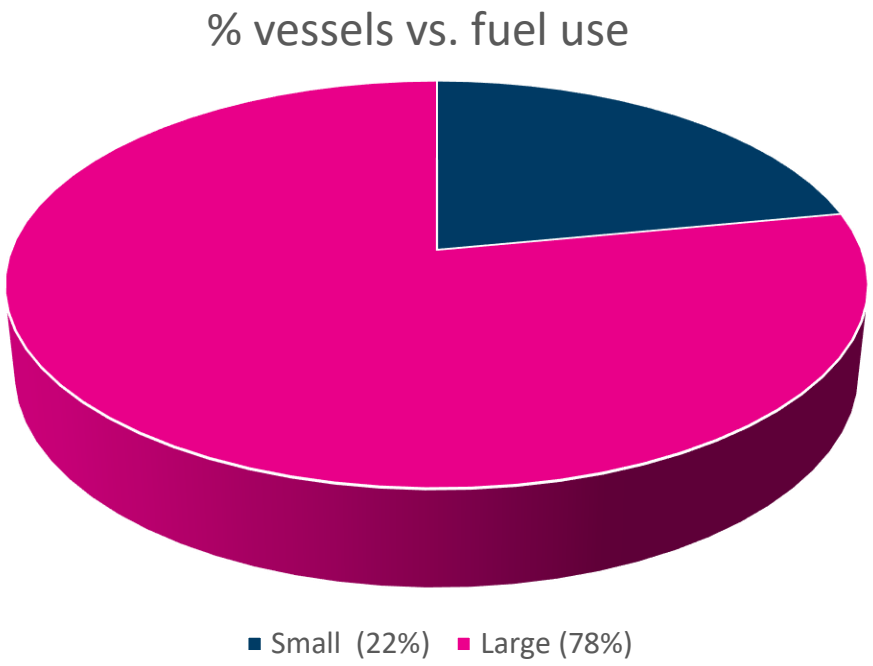
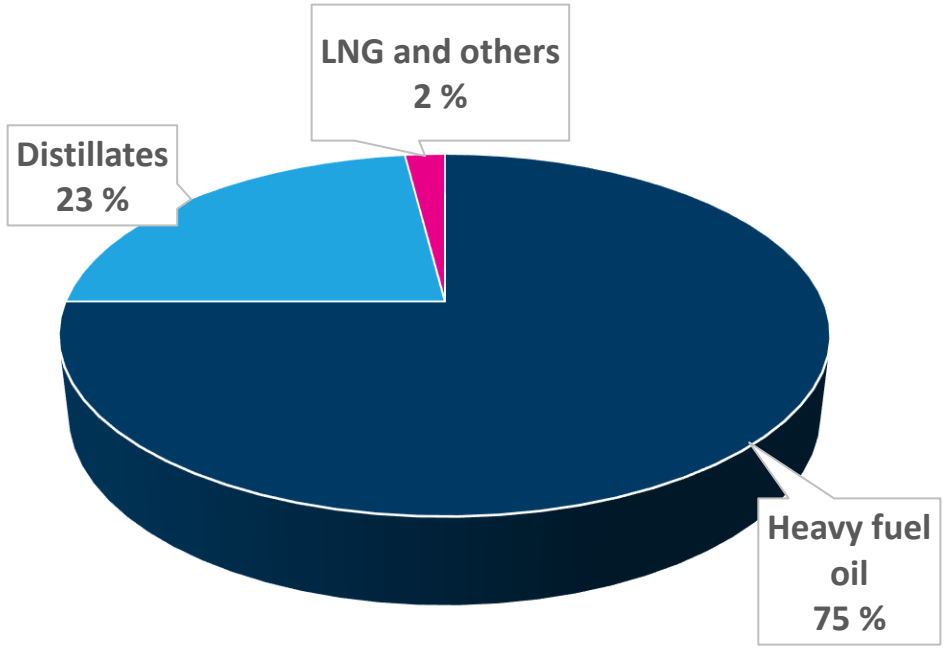
Vessel sizes and consumption

250 - 300 million tons of oil equivalents per year





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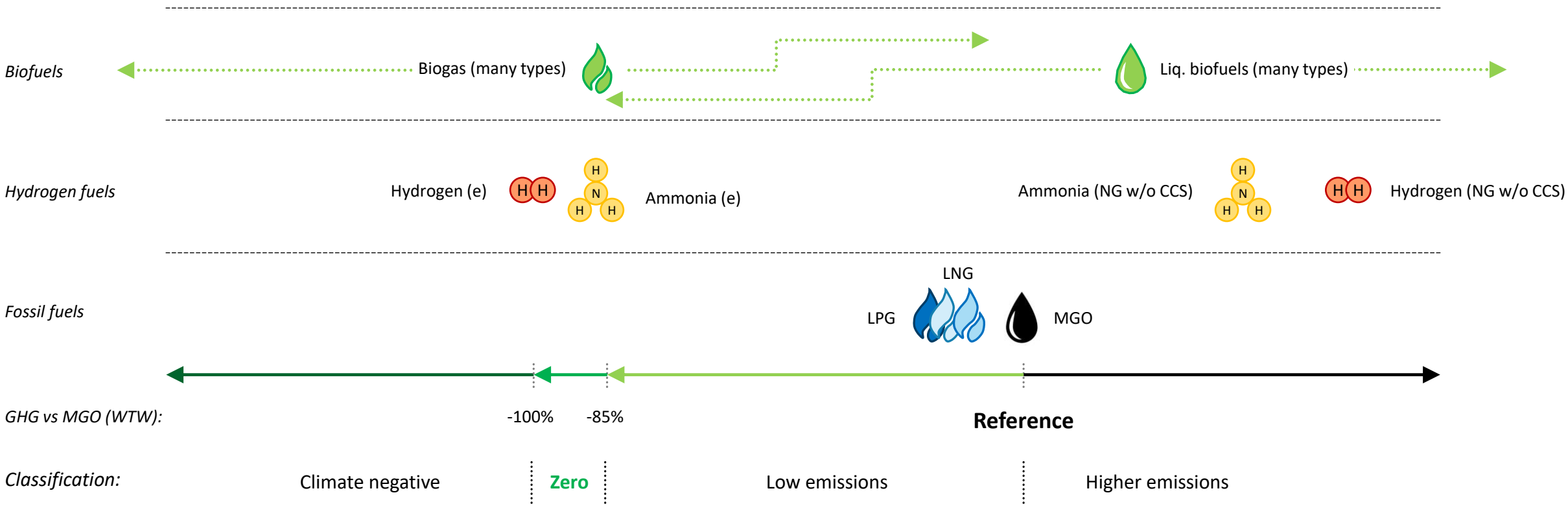
Classification of low and zero emissions



Hydrogen, ammonia and biogas can be produced in different ways, with very different footprint WTT.
LNG can be combusted in Diesel and Otto engines with different levels of methane slip.
Different opinions exist, no clear definition or consensus on the classification.

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

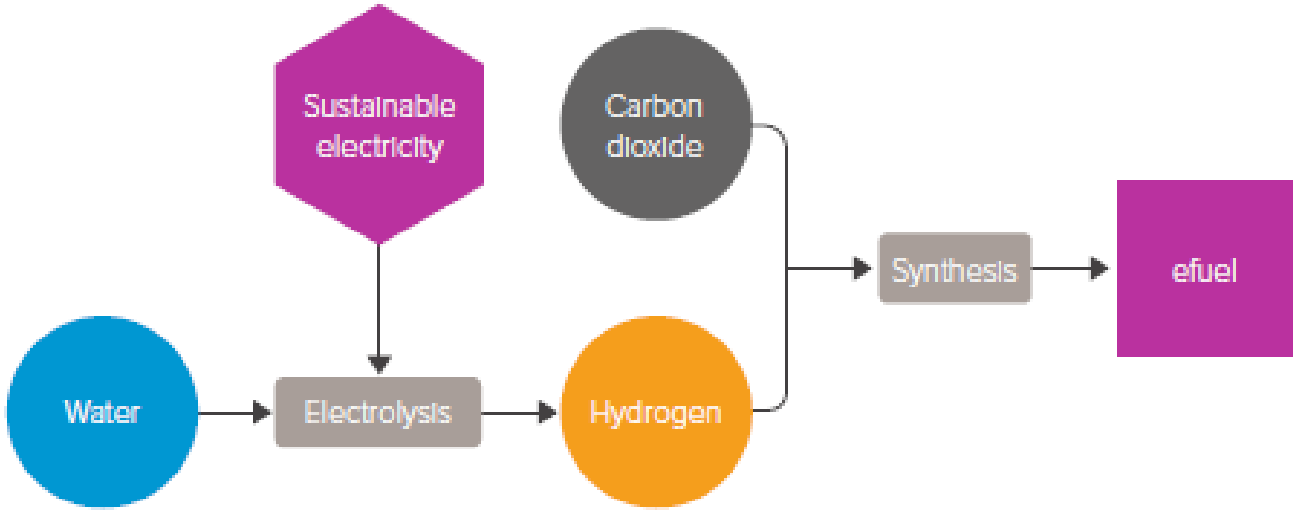
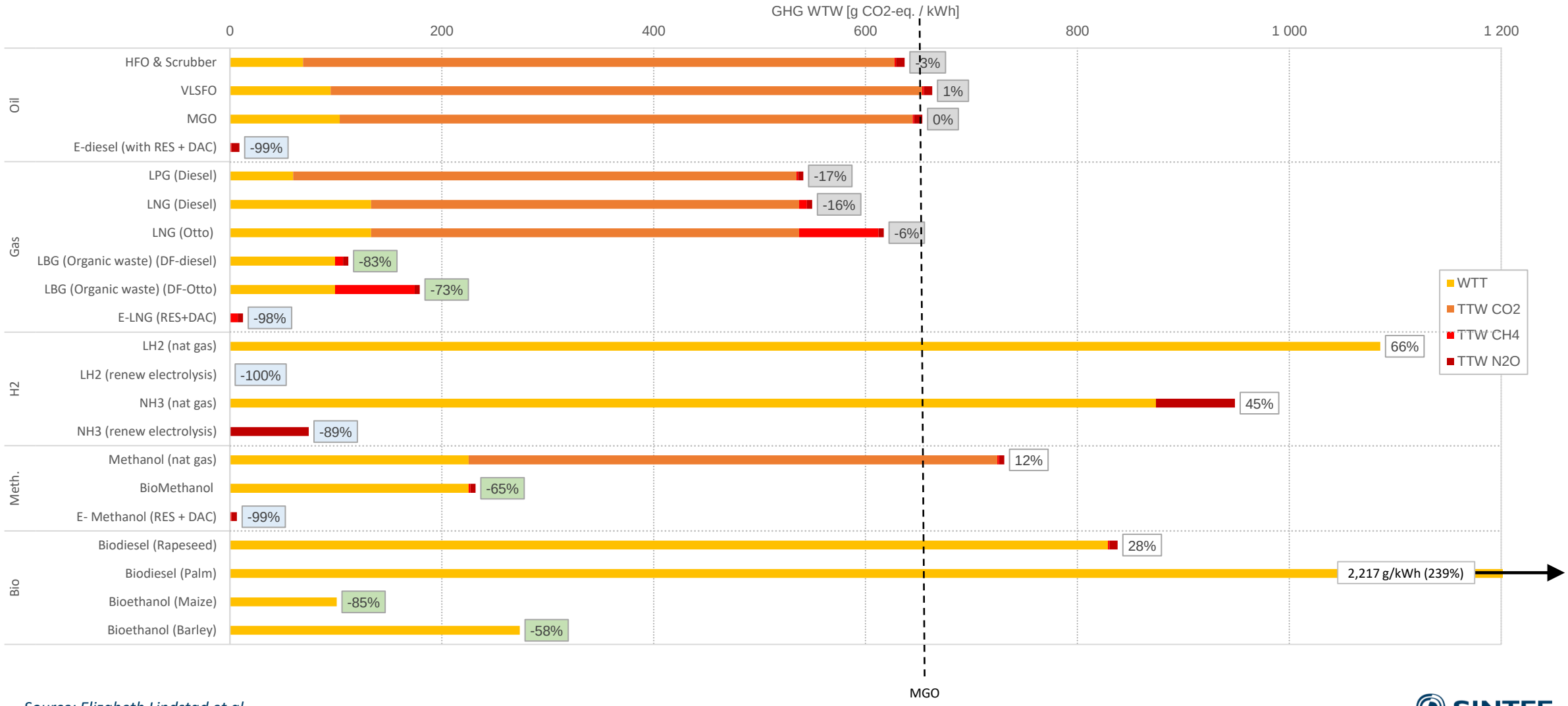


Figure Source: The Royal Society (2019)

Emissions well to wake (WTW = WTT+TTW)

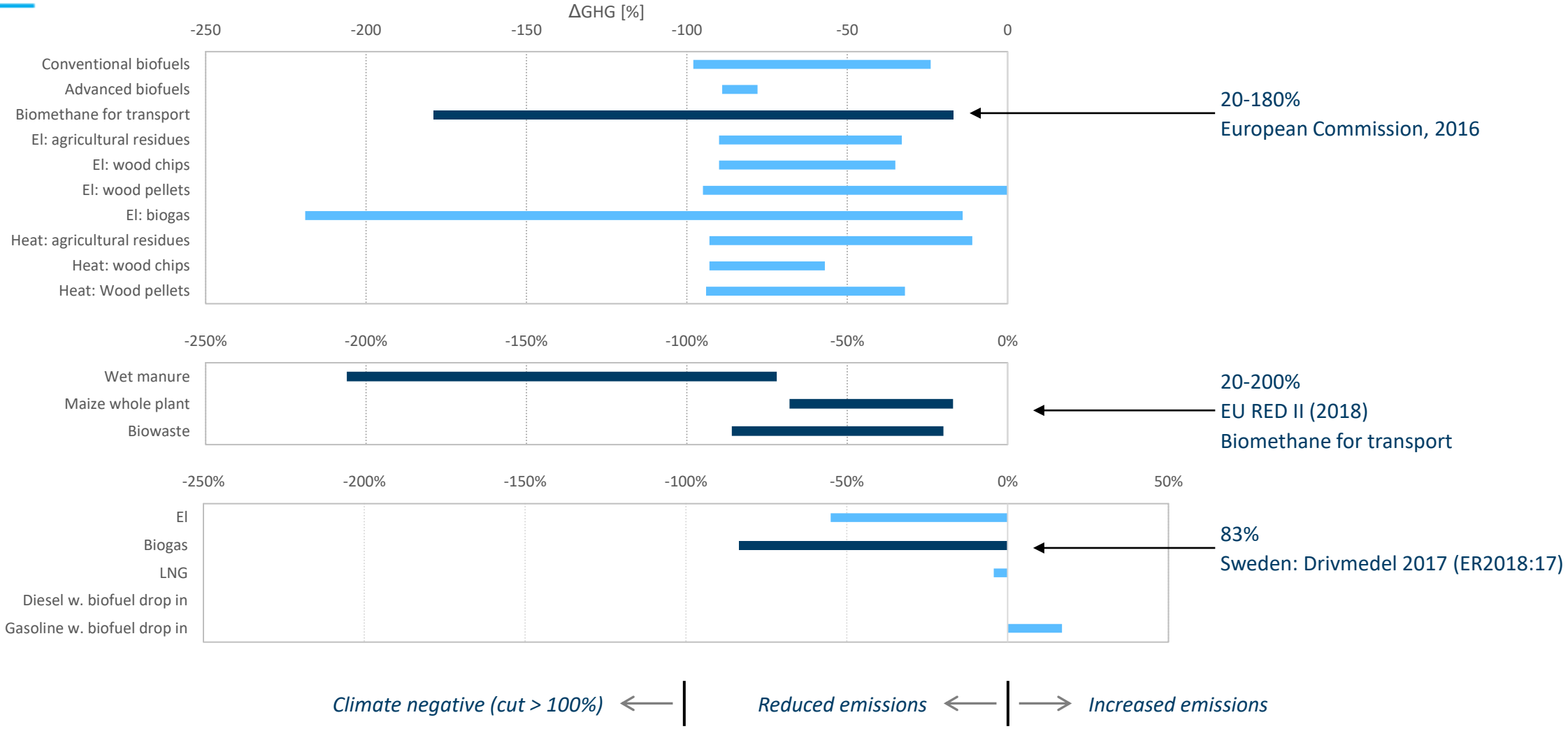


Source: Elizabeth Lindstad et al.

While we know that the type of engine (Diesel or Otto) affect the GHG from LNG, we do not know exactly how the type of engine or fuel cell will impact the emissions with H2 and NH3

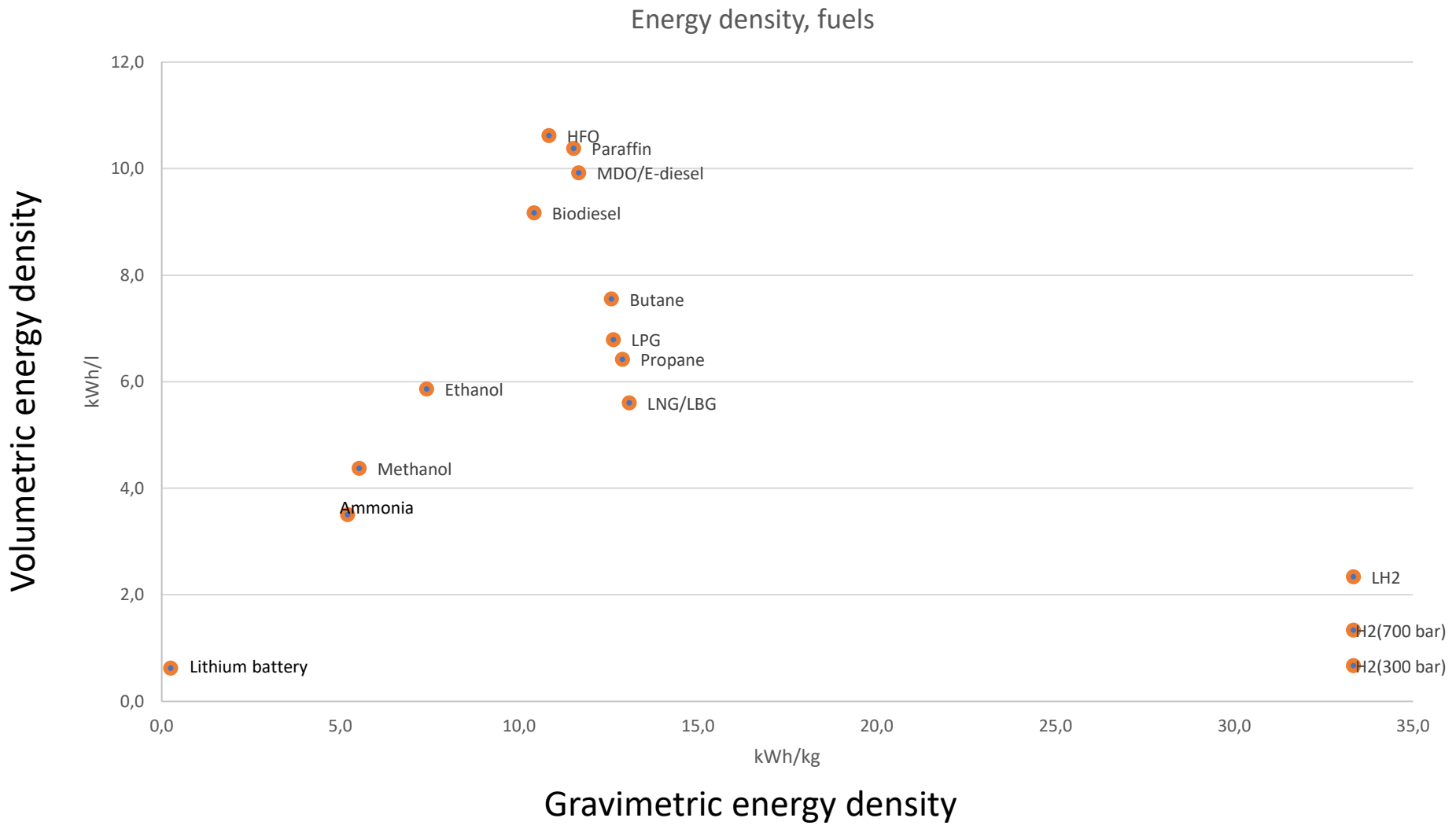
Blue colour indicate fuels which depend on renewable electricity to deliver the GHG reductions indicated. Green colour indicate biofuels. Grey indicate fossil fuels.

Biogas: The GHG-saving varies and depends!

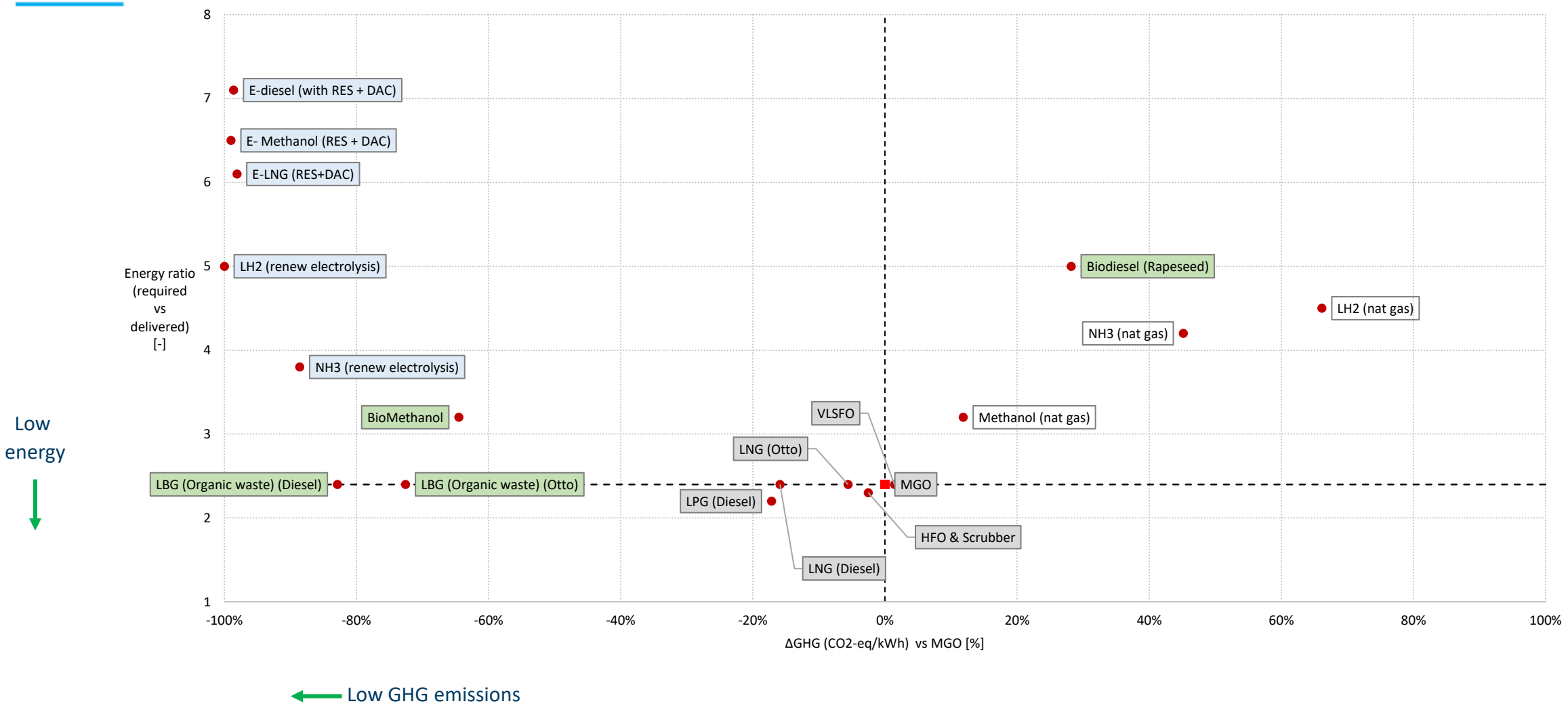


EU RED II (renewables energy directive), 2018 (s. 97), IEA, Technology roadmap, Delivering sustainable bioenergy, 2017 (tabell 7, s. 51)
Svensk energimyndighet: Drivmedel 2017, (tabell 11, s. 33)

THE FUEL MENU – ENERGY DENSITY



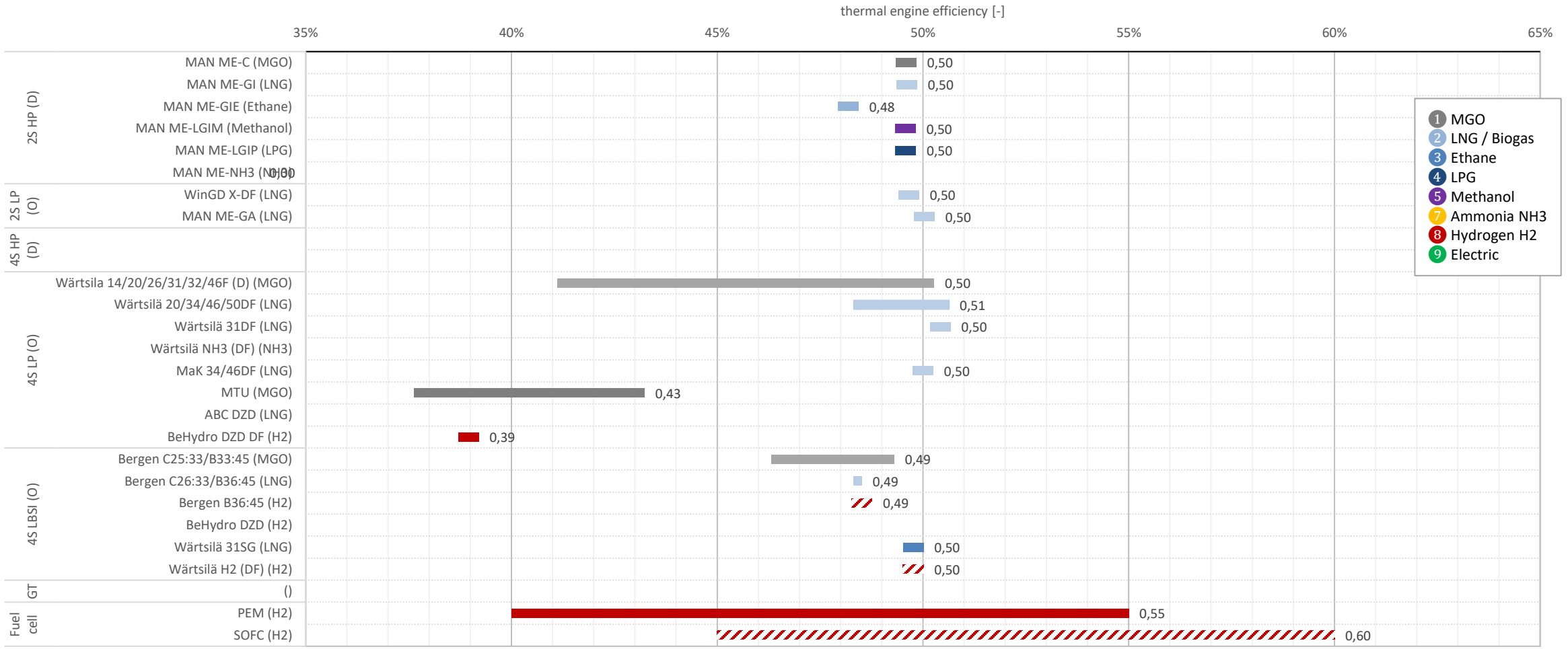
Emissions and energy use well to wake



Source: Elizabeth Lindstad et al

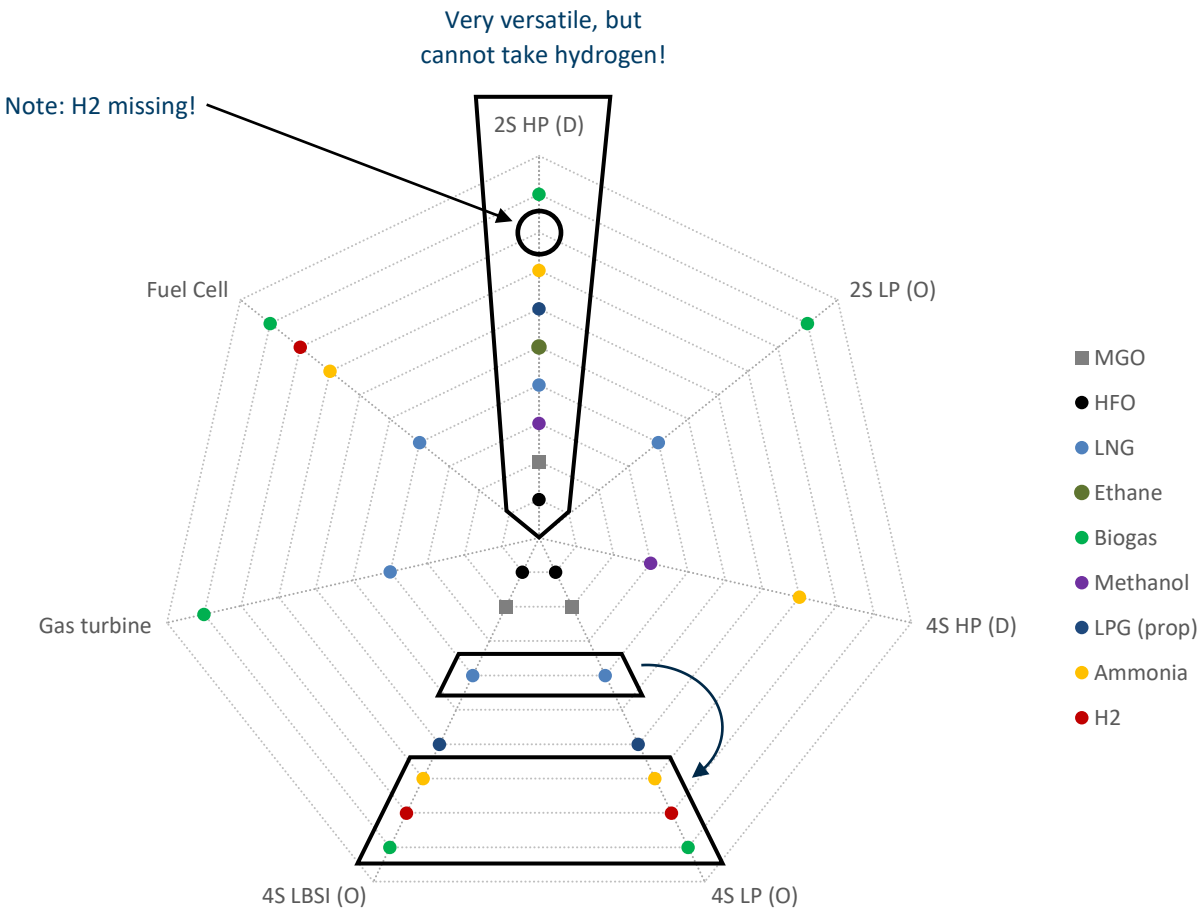
Blue colour indicate fuels which depend on renewable electricity to deliver the GHG reductions indicated. Green colour indicate biofuels. Grey indicate fossil fuels.

Various existing engines and fuel cells



Based on news, articles and direct dialogue with MAN, Wärtsilä and Bergen Engines (May 2021).
Efficiency for new engines assumed based on parent engine in lack of makers' guidance, i.e. all reservations must be taken on the above for engines under development!

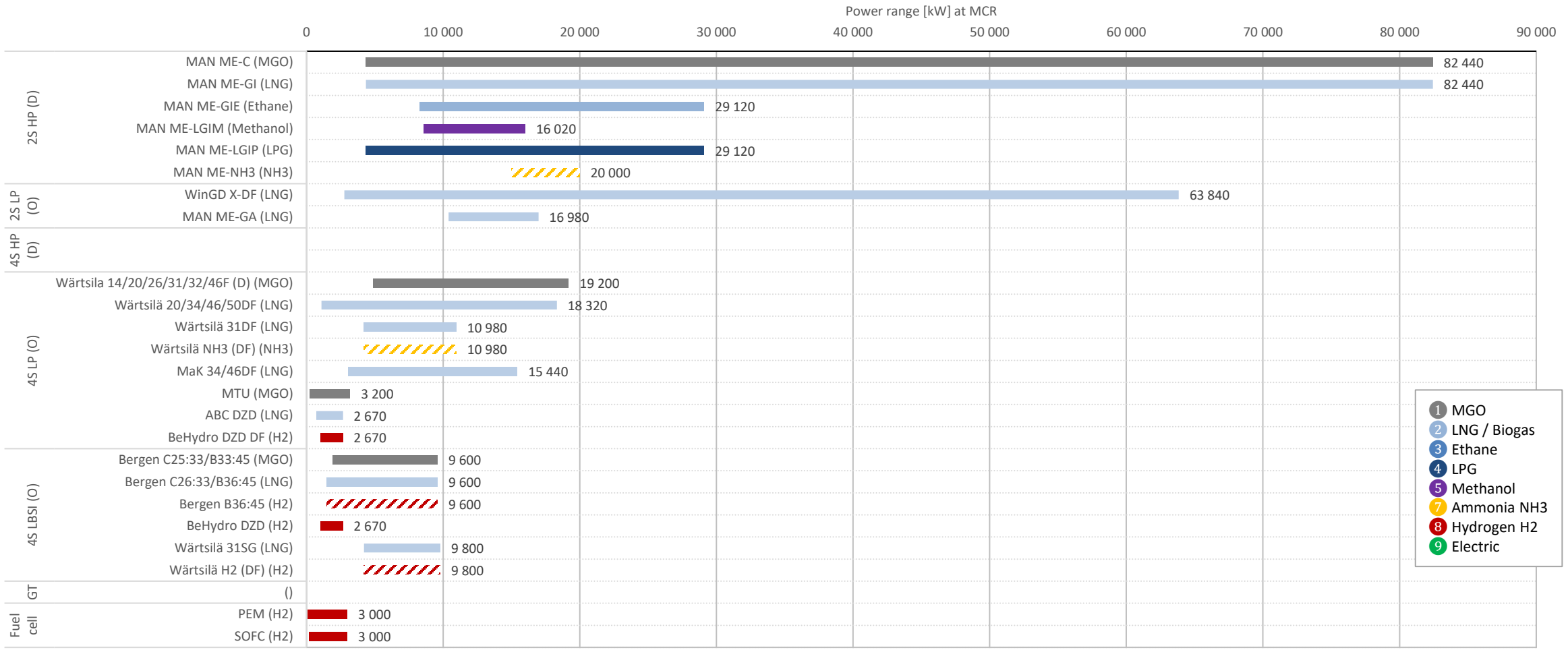
Machinery and fuel combinations



	Stroke	*Pressure*	*Principle*	*Maker (examples, major)*
2S HP (D)	2	High	Diesel	MAN, WinGD, Kobe Diesel
2S LP (O)	2	Low	Otto	WinGD, MAN
4S HP (D)	4	High	Diesel	-
4S (LP (O)	4	Low	Otto	Wärtsilä, MaK +++
4S LBSI (O)	4	Low	Lean burn, spark ignited	Bergen ++
Gas turbine				
Fuel cell			PEM or SOFC	Ballard, PowerCell

Based on news, articles and direct dialogue with MAN, Wärtsilä and Bergen Engines (May 2021).
Power range for new engines assumed based on parent engine in lack of makers' guidance.

Existing DF and machinery for new fuels under development



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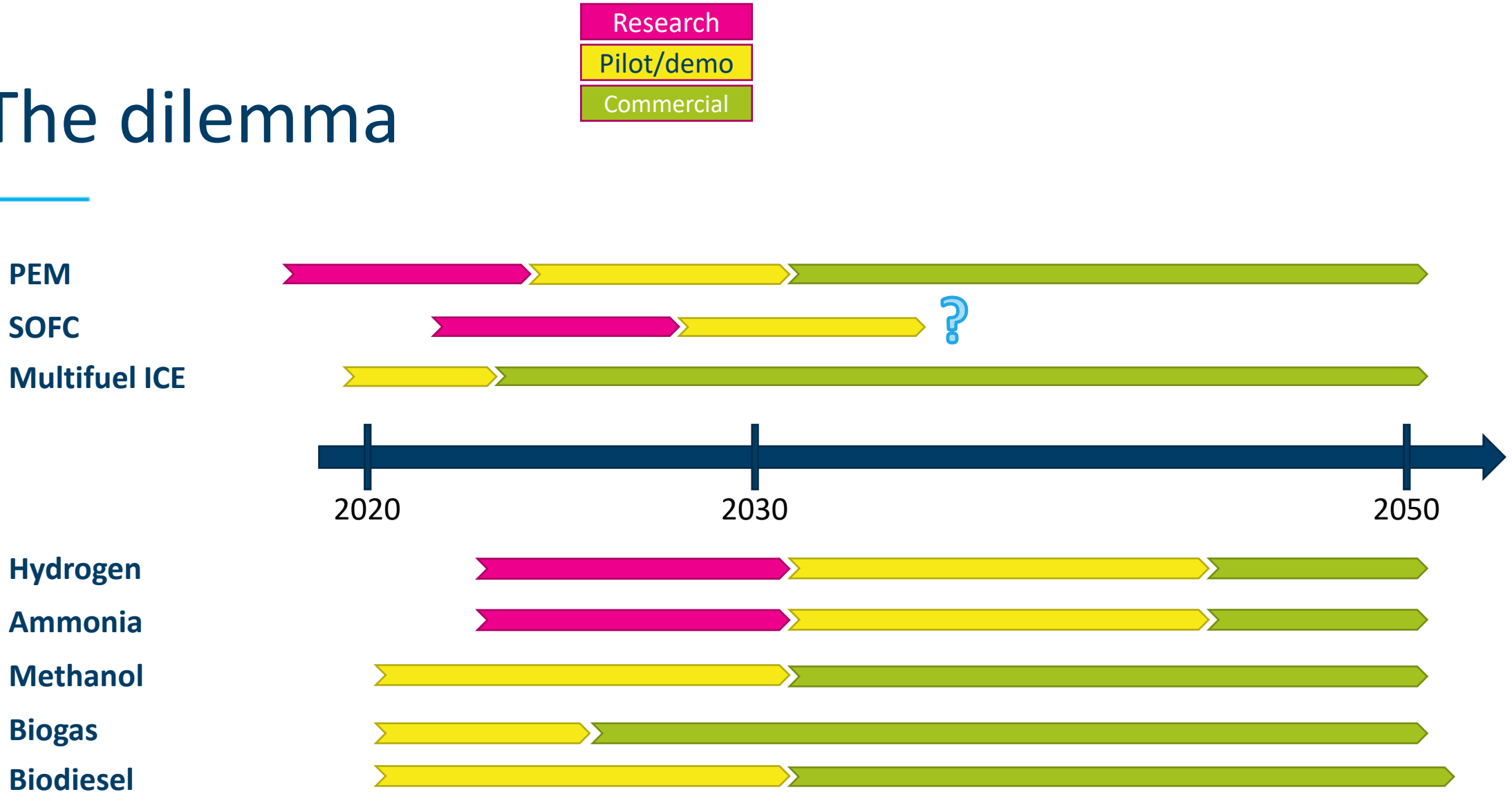
The dilemma



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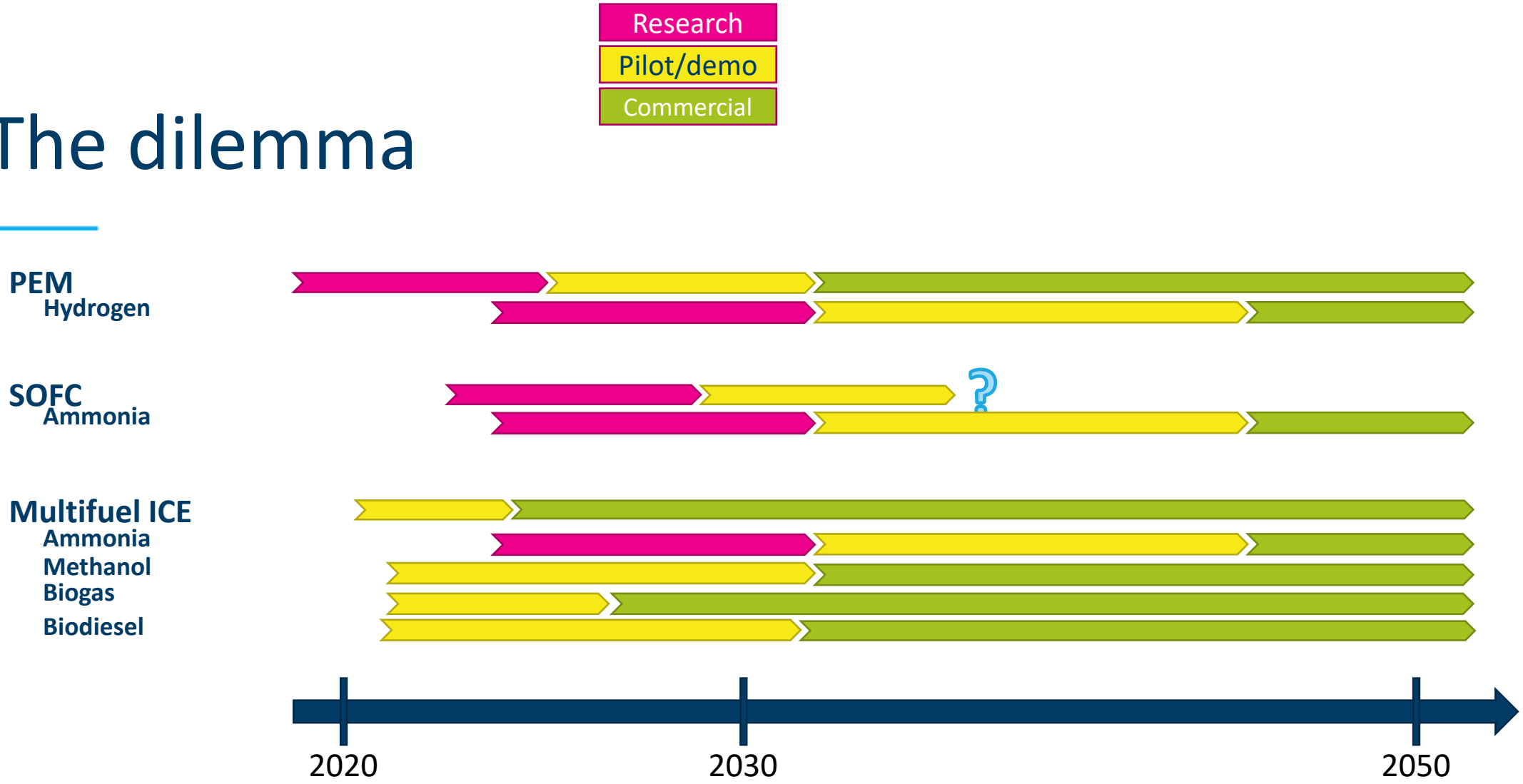
The dilemma


Research
Pilot/demo
Commercial
PEM
Hydrogen
SOFC
Ammonia
Multifuel ICE
Ammonia
Methanol
Biogas
Biodiesel
2020
2030
2050

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Teknologi for et bedre samfunn