Høgskulen
på Vestlandet

Biofuels vs. hydrogen / ammonia: Pros & Cons

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The role of biofuel in maritime operations

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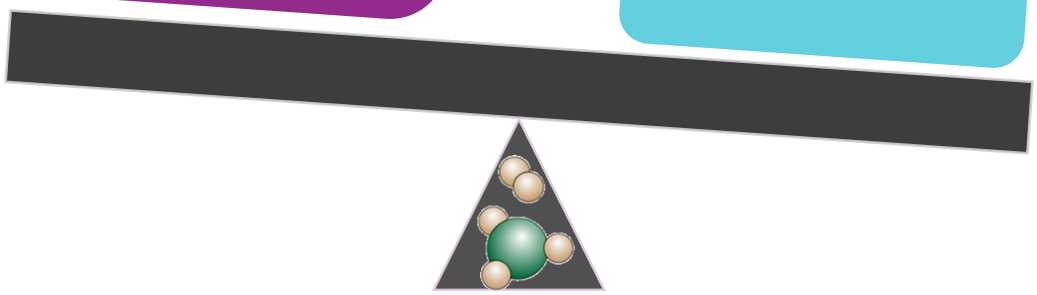
For more on hydrogen, ammonia and green energy

Velaug Myrseth Oltedal

Norbert Lümmen

Pros & Cons

+	-	+	-
Compliance	Availability and TRL	Carbon neutral at best	Availability
Carbon free energy conversion	Logistics	Use of existing infra. & tech	Costs
	Costs		



Some terms and definitions

› What's ''bio''?

Biofuels are liquid fuels made from biomass and consumed in transport. The most important biofuels today are bioethanol (made from sugar and cereal crops) used to replace petrol, and biodiesel (made mainly from vegetable oils) used to replace diesel.

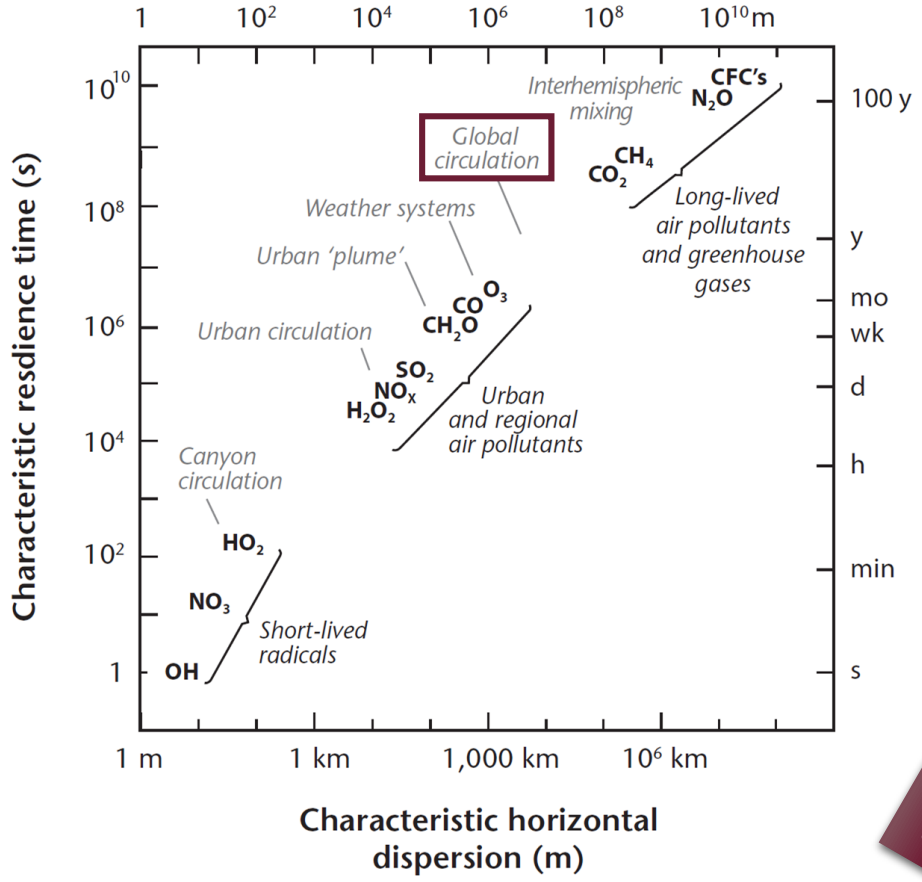
Bioliquids are liquid fuels made from biomass and used to produce electricity, heating or cooling.

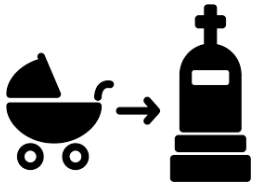
Biomass fuels are solid or gaseous fuels made from biomass.

Therefore, all these fuels are made from biomass. They have different names depending on their physical nature (solid, gaseous or liquid) and their use (in transport or to produce electricity, heating or cooling).

''bio'' \ (H2, NH3 and synt. fuel)

› Climate / environment



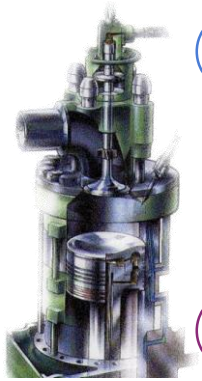


a little gas goes a long way

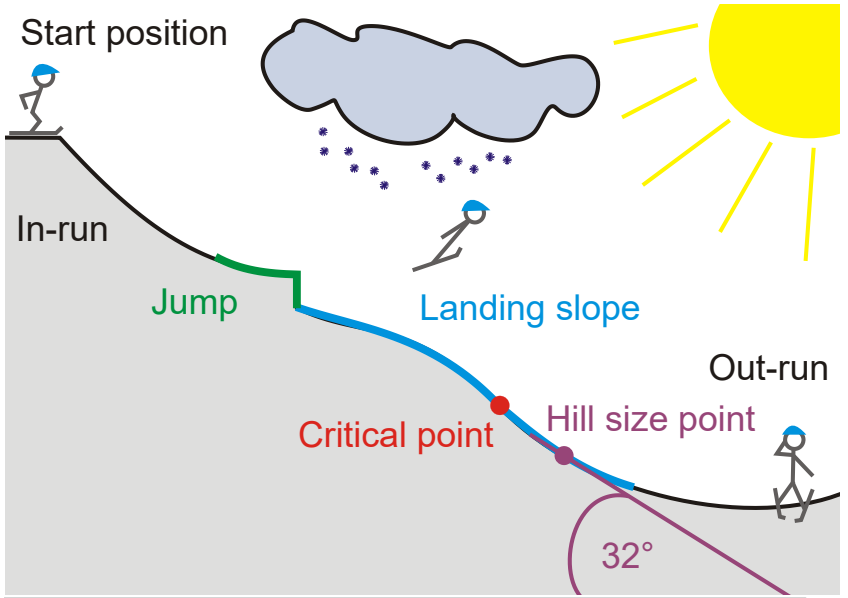
Source: European commission fact sheet; Sustainability criteria for biofuels specified; 13.03.2019
Oke, T., Mills, G., Christen, A., & Voogt, J. (2017). Air Pollution, Urban Climates, 294-331

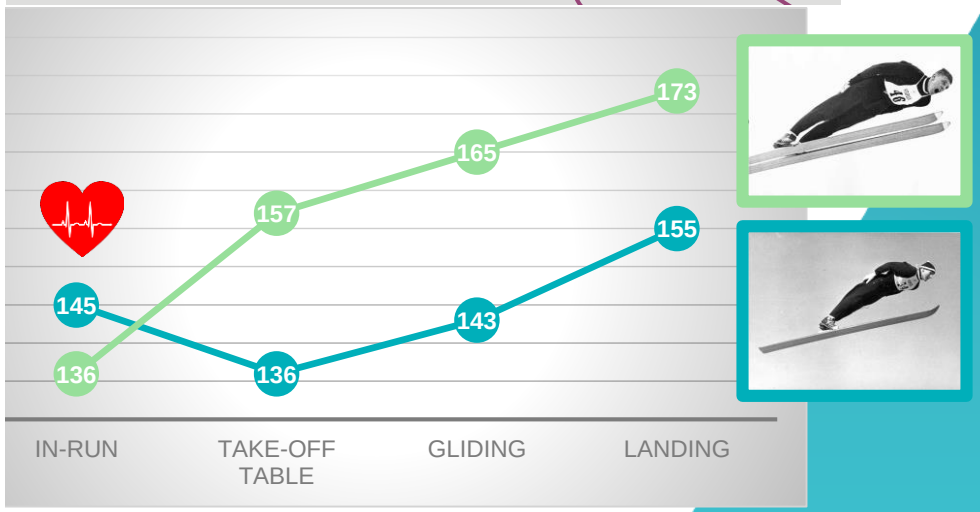
“Jumping after Wirkola”

“The common parlance expression jumping after Wirkola has come to refer to situations where one embarks on a task where one's predecessor has done a particularly good job – or where one is unlikely to succeed.”



- Investment costs
- Fuel and operating costs
- Fuel availability and infrastructure
- Reliability and maintenance
- Ship design
- Rules and regulations





Source: Wikipedia /SAMTIDSRUINAR, Marit Eikemo, 2015

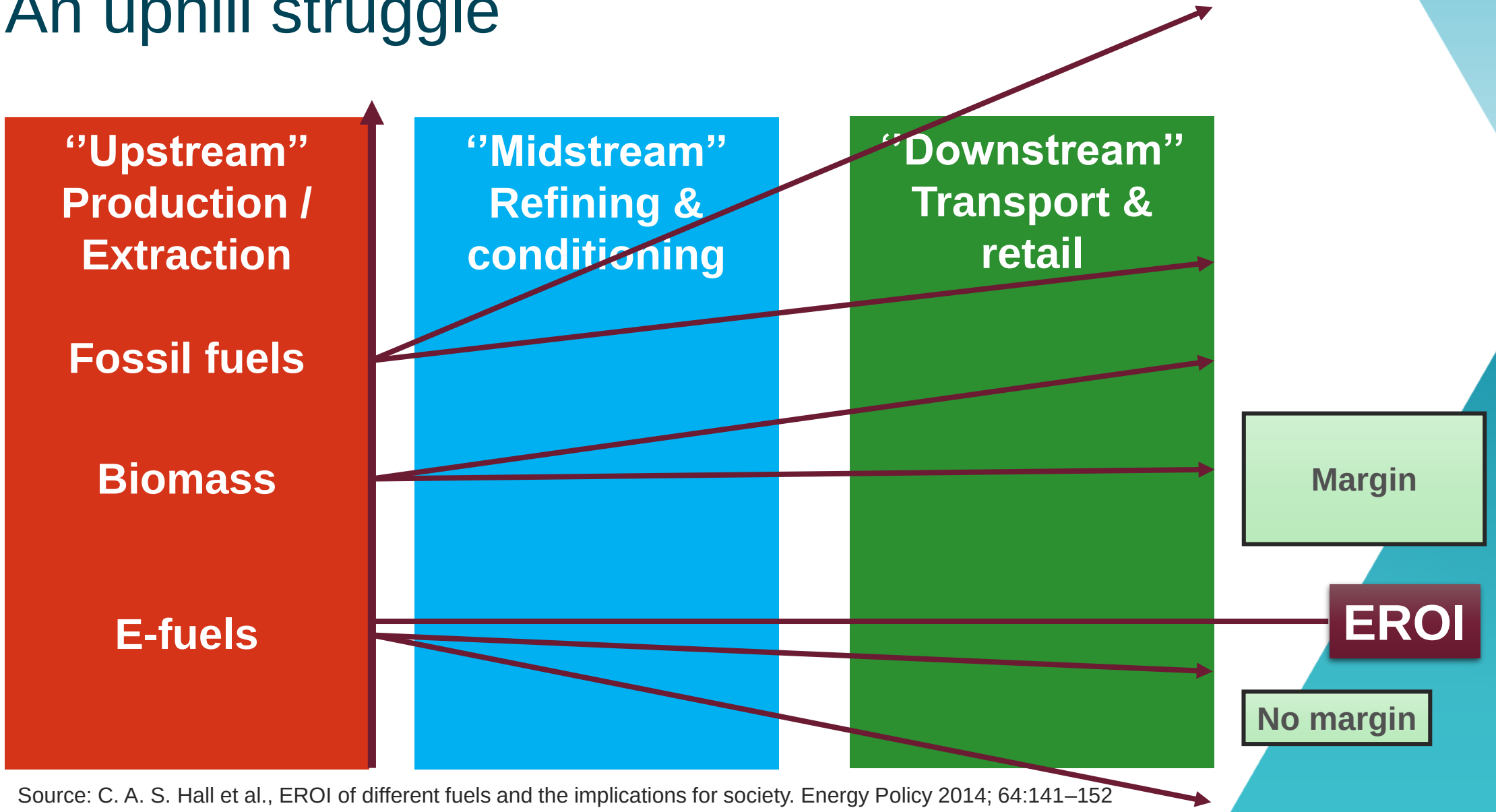
Some numbers

Parameter	Unit	NH3	H2	NG	Diesel	MeOH	FAME	HVO
Lower heating value	MJ/kg	18,8	120	47	39 - 43	20	37	44
	MJ/m3	13,7	9,8	36	38,6 - 36	15,9	33	34
Flashpoint	°C	NA	NA	-188	>55	11-12	>100	>61 / 70
Min. ignition energy	mJ	>>1 (680)	0,01 – 0,02	0,28	NA	0,14	NA	NA
Lam. Flame speed	m/s	0,07	3,5	0,38	0,3 – 0,4	0,5	< diesel	~diesel
Flammability limit in air	%	15 - 28	4 - 75	5 - 15	0,6 – 7,5	6,7 - 36	diesel	diesel

Source: DNV GL Alternative Fuels Insights (AFI)

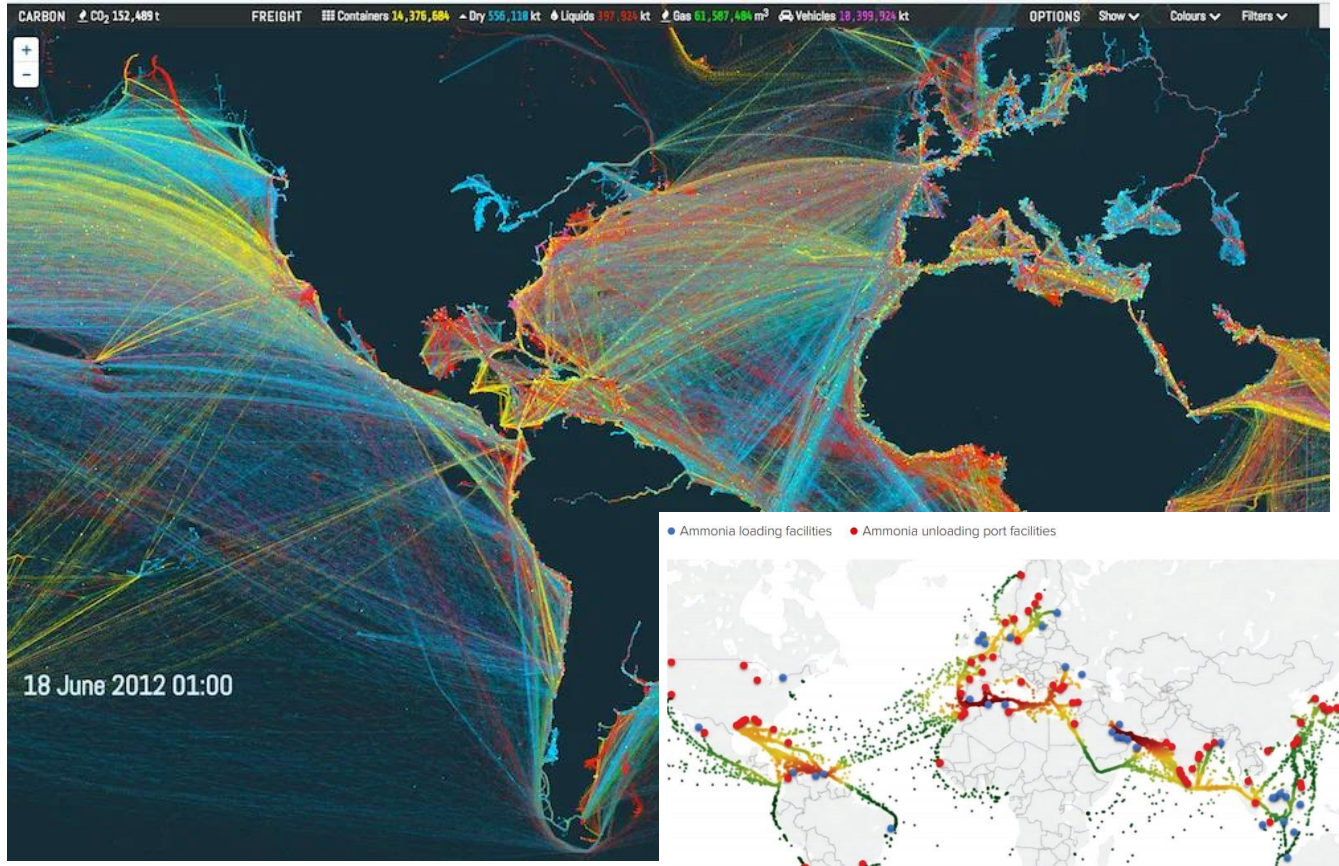
A. Valera-Medina et al., Ammonia for power, Progress in Energy and Combustion Science 69 (2018), s. 63–102

An uphill struggle



Source: C. A. S. Hall et al., EROI of different fuels and the implications for society. Energy Policy 2014; 64:141–152
H. Blanco et al., Potential for hydrogen and Power-to-Liquid in a low-carbon EU energy system using cost optimization. Applied Energy 232 (2018) 617–639

Where you at?!



HFO
MGO

Fuel Energy meter

LNG

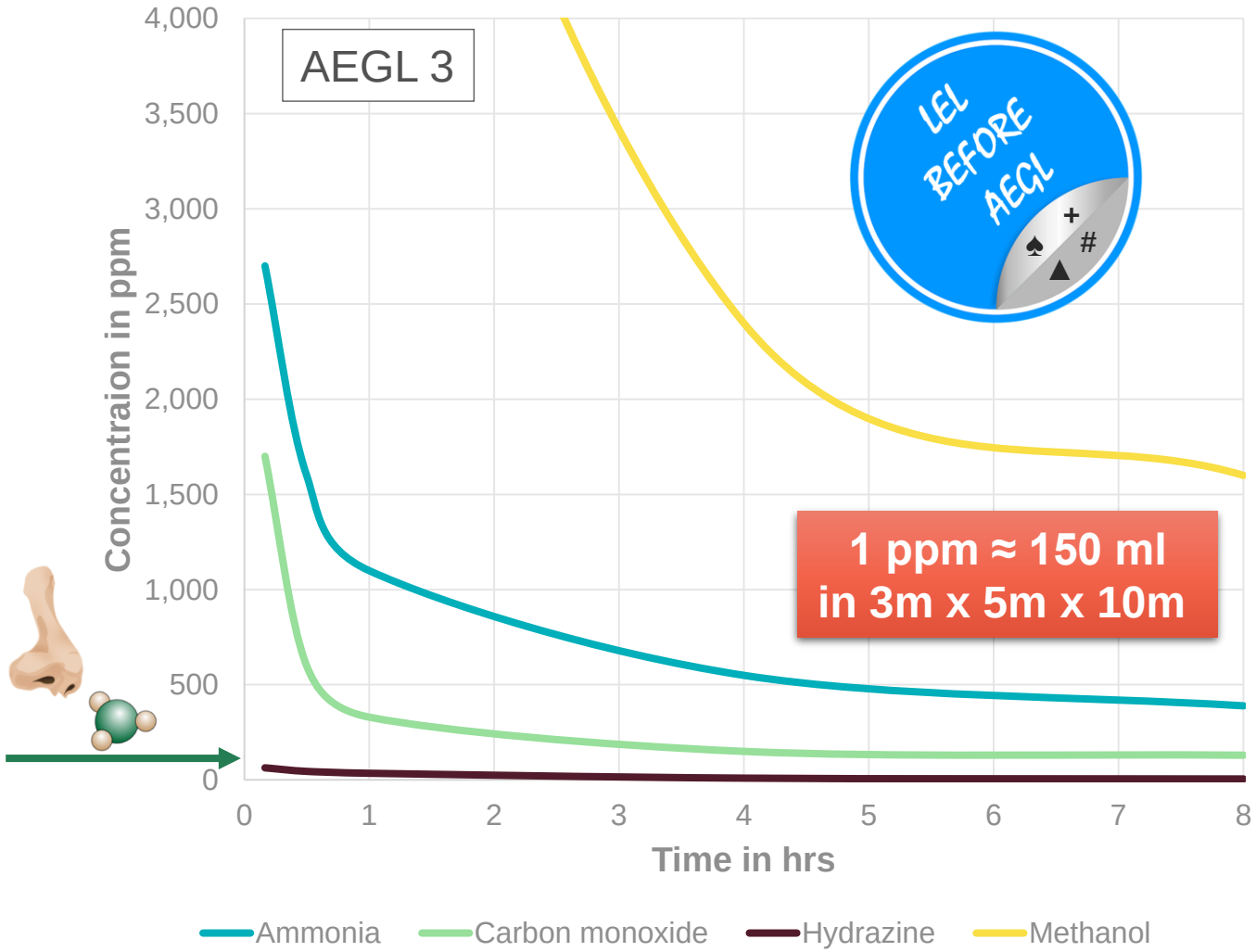
FAME

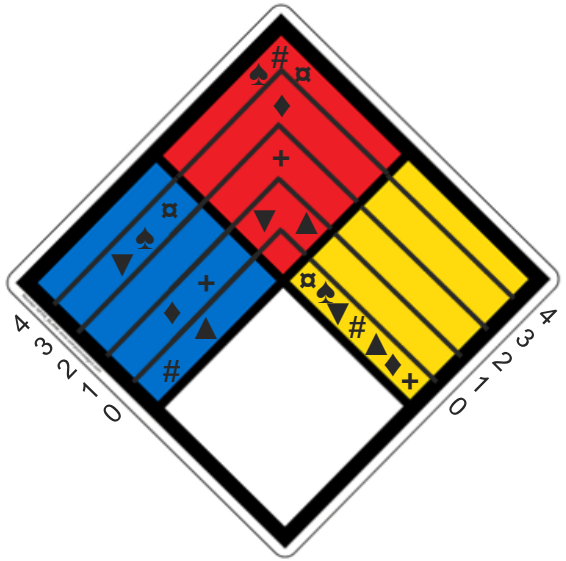
H2

MeOH

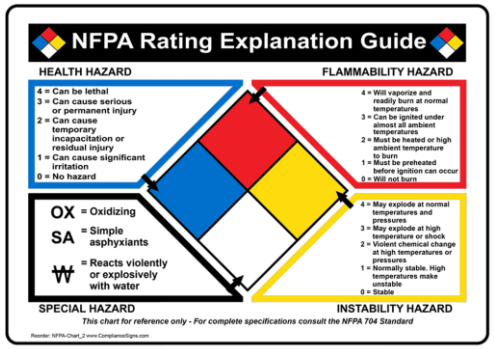
Source: https://www.ucl.ac.uk/bartlett/energy/files/stunning-map-global-shipping / https://www.shipmap.org / www. nist.gov
DNV GL Alternative Fuels Insights (AFI) / The Royal Society. Ammonia: zero-carbon fertiliser, fuel and energy store

Some thoughts on safety



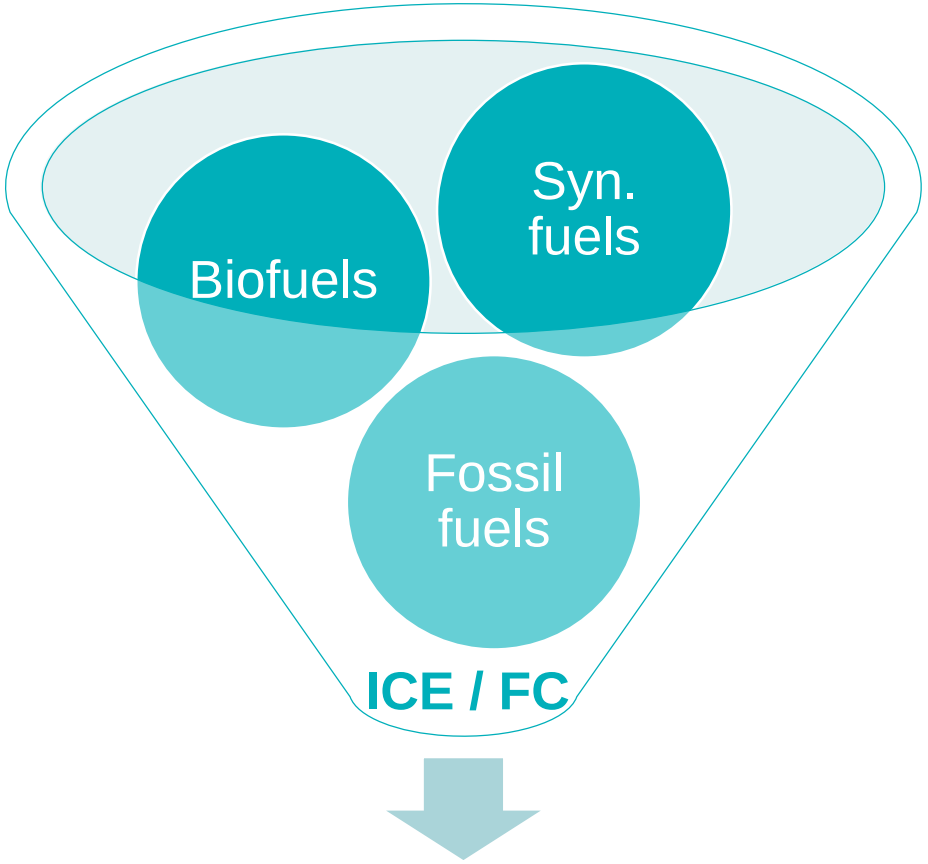


▼ Ammonia
\# Hydrogen
¤ LH2
♠ LNG
♦ Methanol
\+ Diesel
▲ Biodiesel



Source: US EPA Acute Exposure Guideline Levels for Airborne Chemicals /
National Fire Protection Association (NFPA) / International Maritime Organization (IMO)

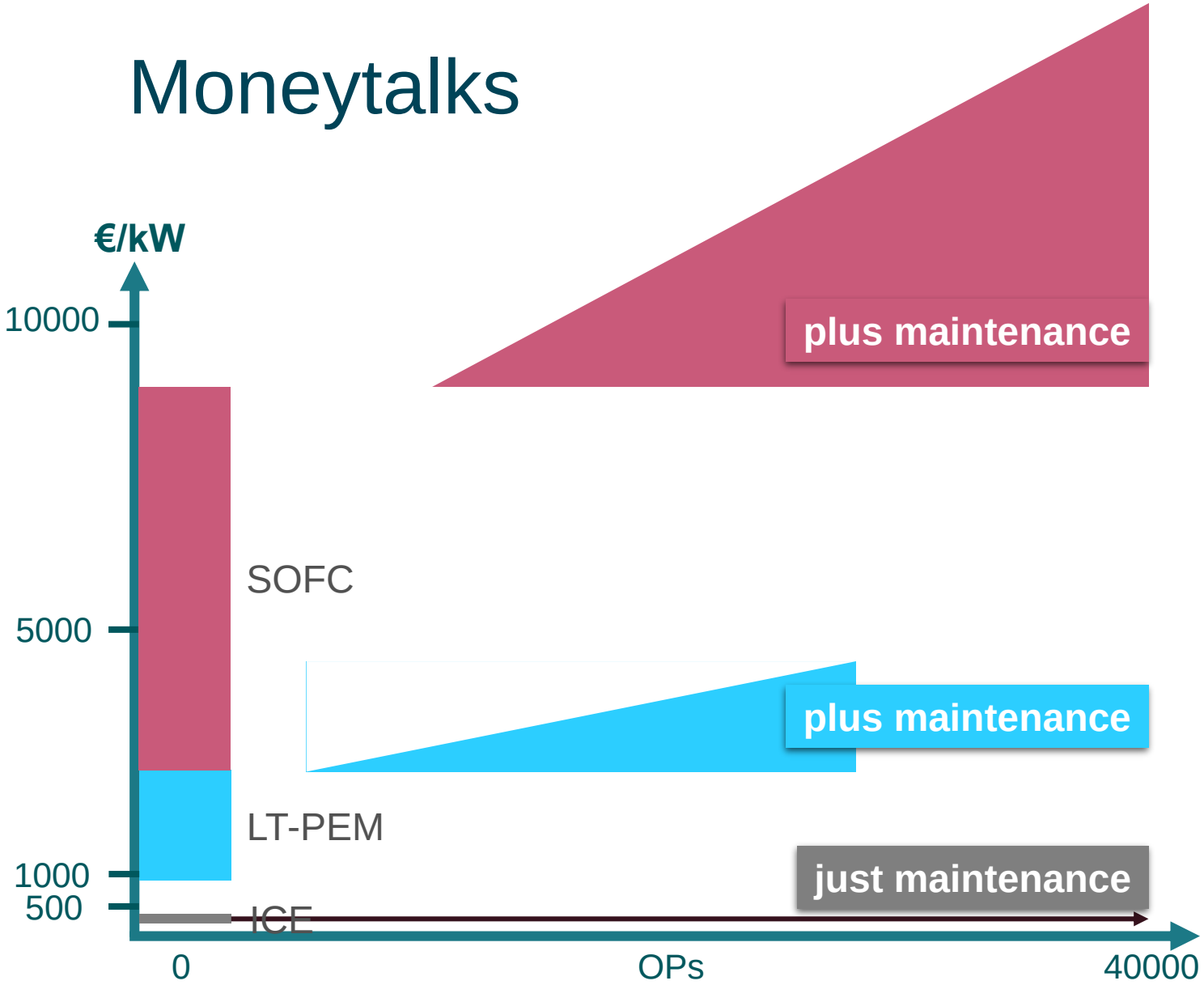
Talking tech

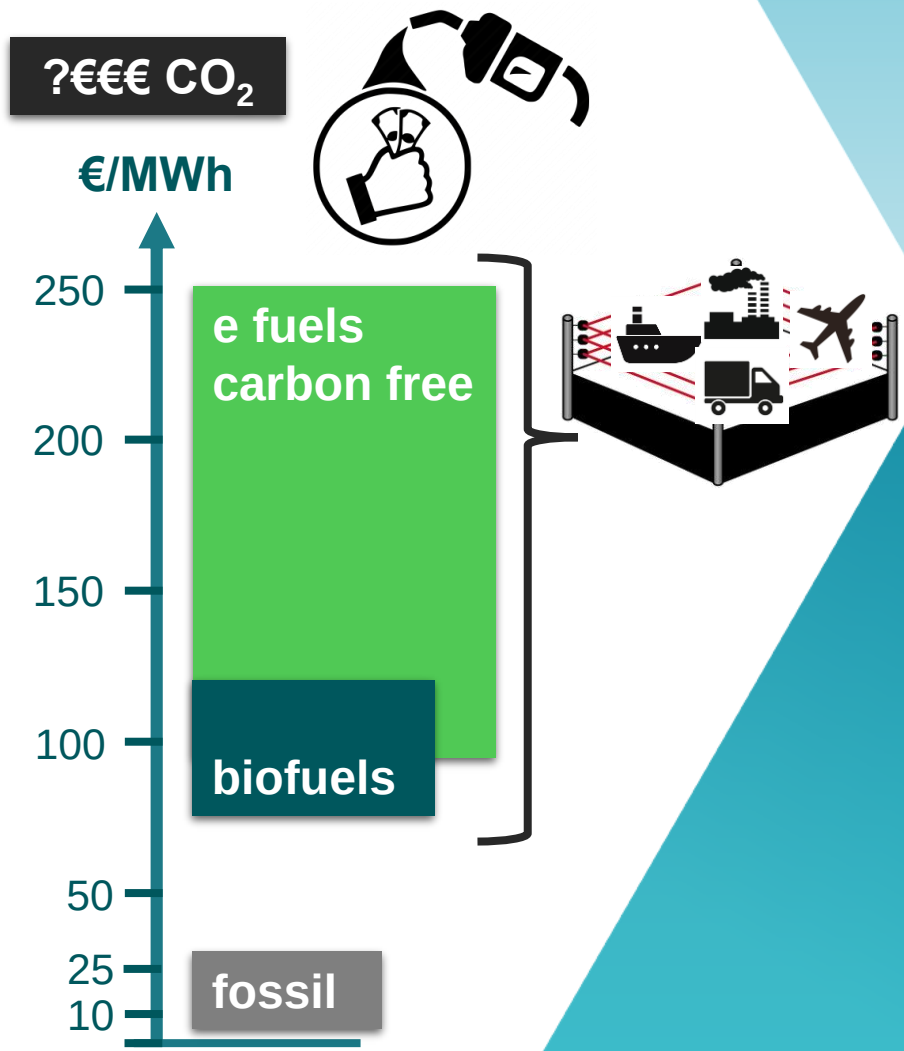


Operating	Typical values*
… temperature	ICE: ~100°C FC: <100°C up to 1000°C
… load (range)	ICE: 100 kW – 80 MW FC: 100 – 2000 kW
… pattern	ICE: dynamic load changes FC: typically with battery systems for cyclic operation
Cold start-up	ICE: mins FC: sec - hrs
Responsiveness	ICE: sec FC: sec – hrs
Technical maturity	ICE: (7-) 9 FC: 6-8 (9)
* depending on type and make	

Source: Various data OEMs
DNV GL, Study on the use of fuel cells in shipping (EMSA), 2017

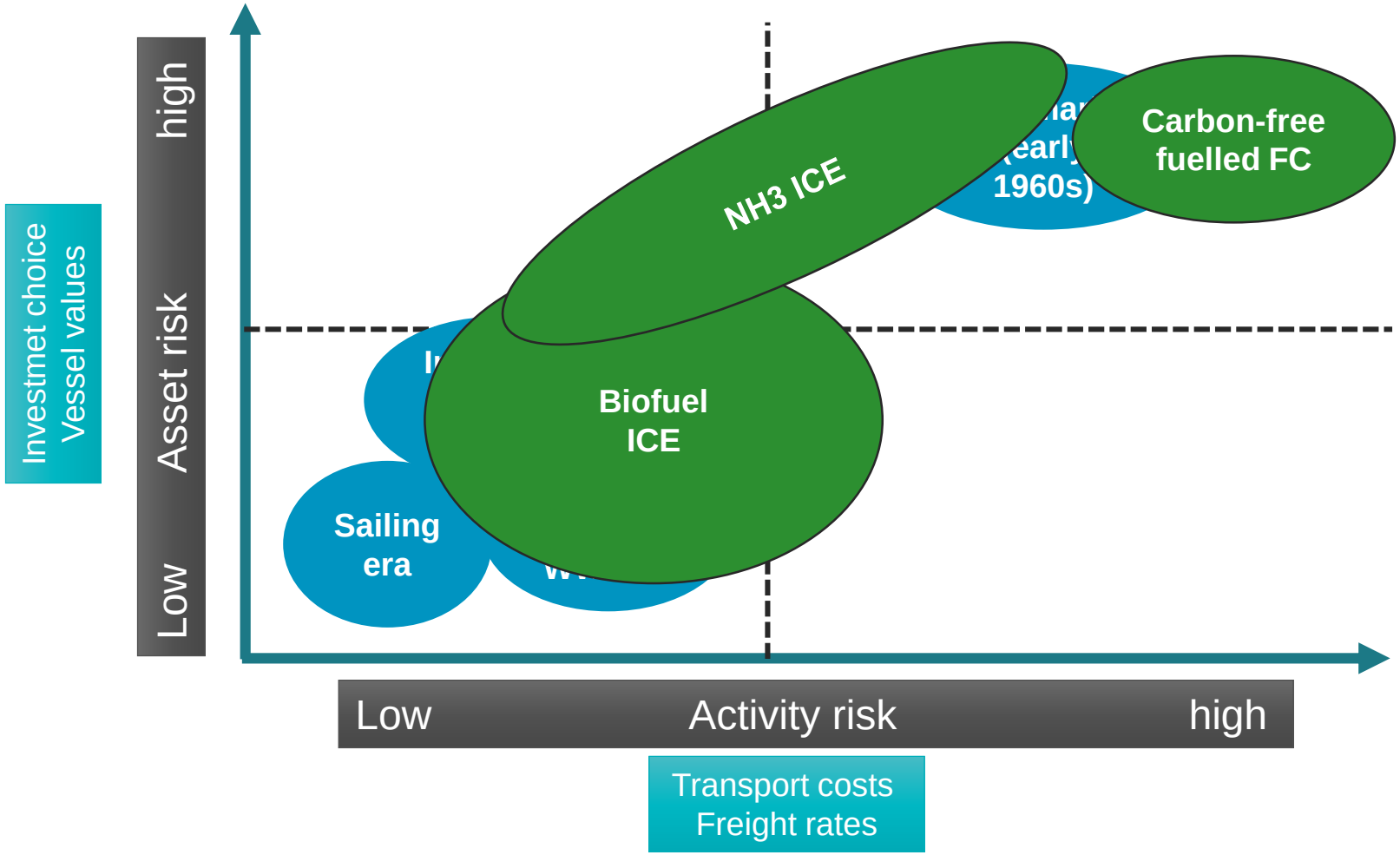
Moneytalks





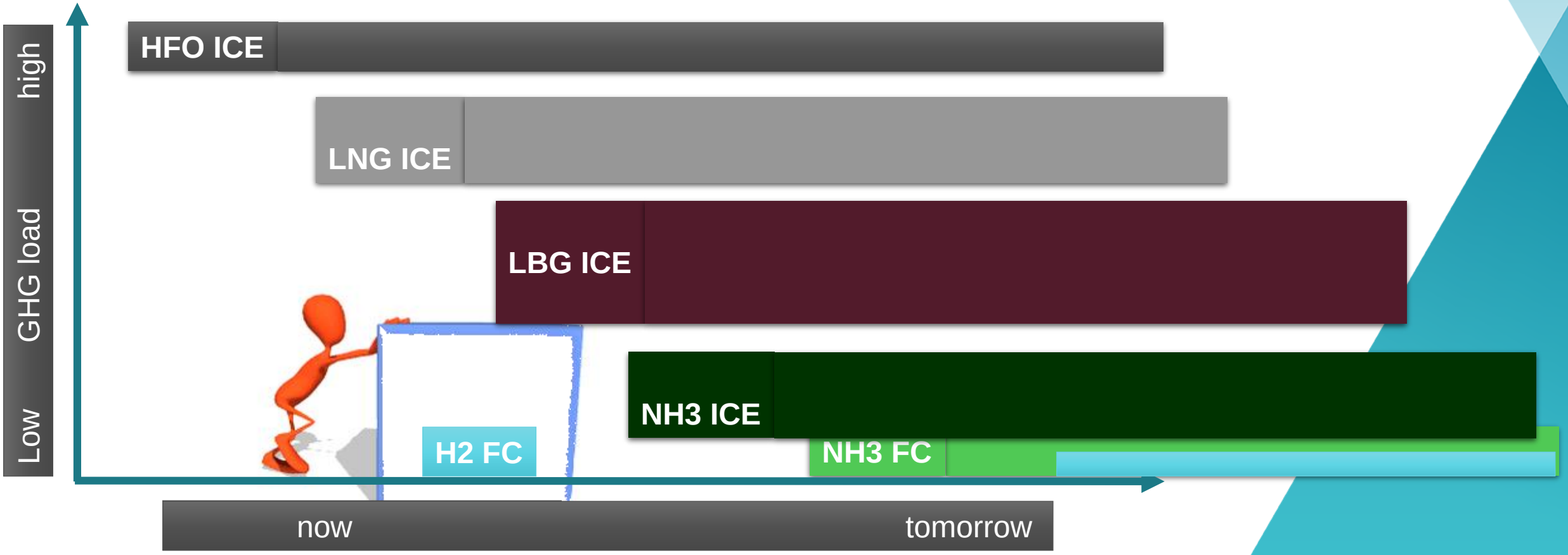
Source: DNV GL Alternative Fuels Insights (AFI)
B. Piga, Feasibility Study of Hydrogen as Fuel for PSV Applications, 2019

A (Norwegian) look back



Source: G. Harlaftis, S. Tenold, J. M. Valdaliso, The World's Key Industry - History and Economics of International Shipping

Staircase conclusion



"IF WE WANT THINGS TO STAY AS THEY ARE, THINGS WILL HAVE TO CHANGE."

GIUSEPPE TOMASI DE LAMPEDUSA