

# Ammonia as Marine Fuel

Looking Back From 2050, William Froude & KIVI MARTEC

Niels de Vries – 19th Feb 2019



**C-JOB**

DEDICATED NAVAL ARCHITECTS

## Bio Fuels

- Maritime industry consumption +/- 12.8 EJ
- Bioenergy assessment: high agreement 100 EJ in 2050 -> IMAREST: availability shipping 4.0 – 11.0 EJ

Climate / Country (as example)	Type	Yield [W/m <sup>2</sup> ]	Required otherwise unproductive land [km <sup>2</sup> ]	* United Kingdom [-]	* The Netherlands [-]
Temperate oceanic / United Kingdom	Rape seed	0.13	3,122,195	12.9x	75x
Temperate oceanic / United Kingdom	Sugar beet	0.40	1,014,713	4.2x	24x
Tropical / Brazil	Sugar cane	1.20	338,238	1.4x	8x

*Table 2-1: Required otherwise unproductive land for bio mass to supply the maritime industry*

\* The number of times the country could fit in the required otherwise unproductive land.





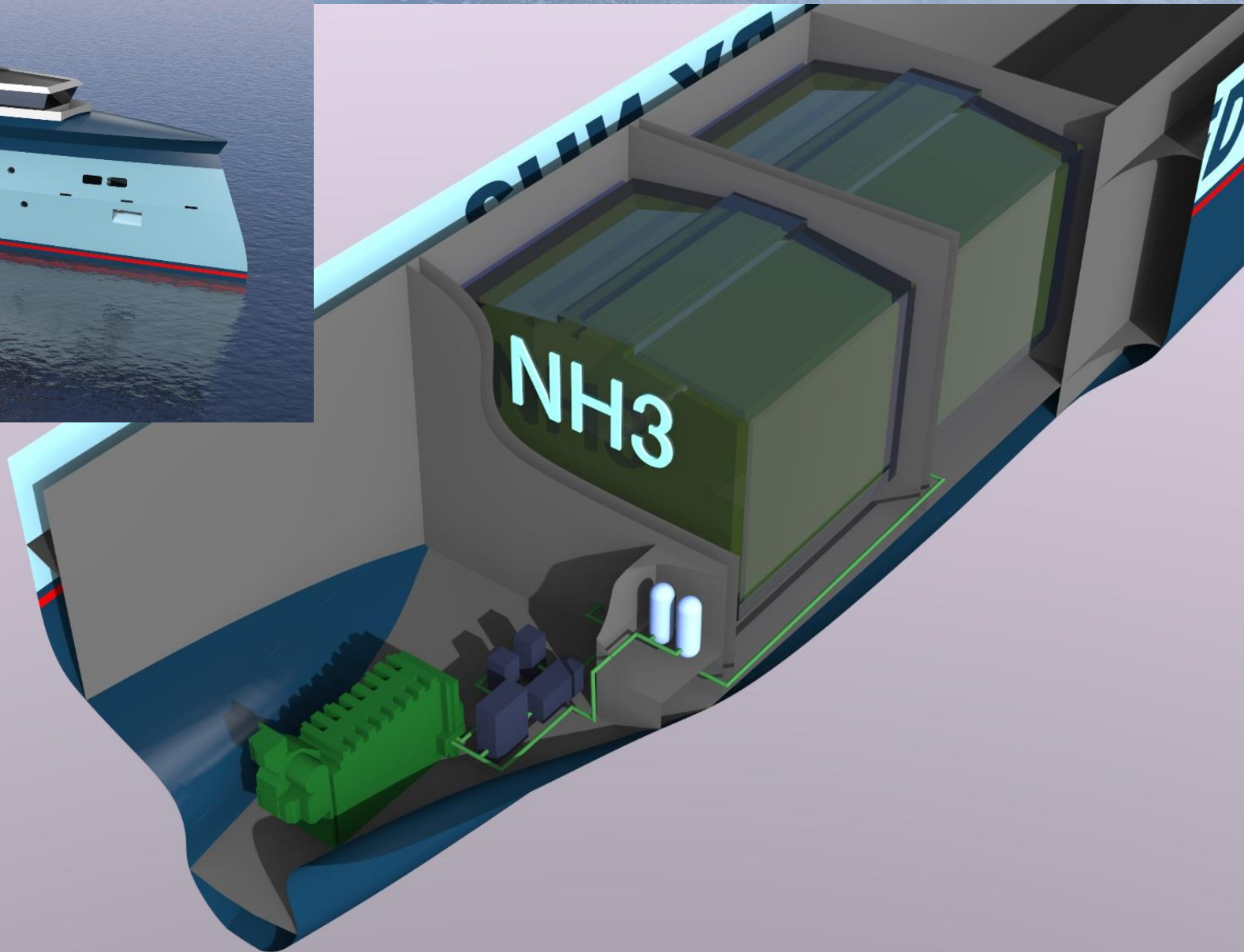




PIONEERS IN THE  
MARITIME SECTOR



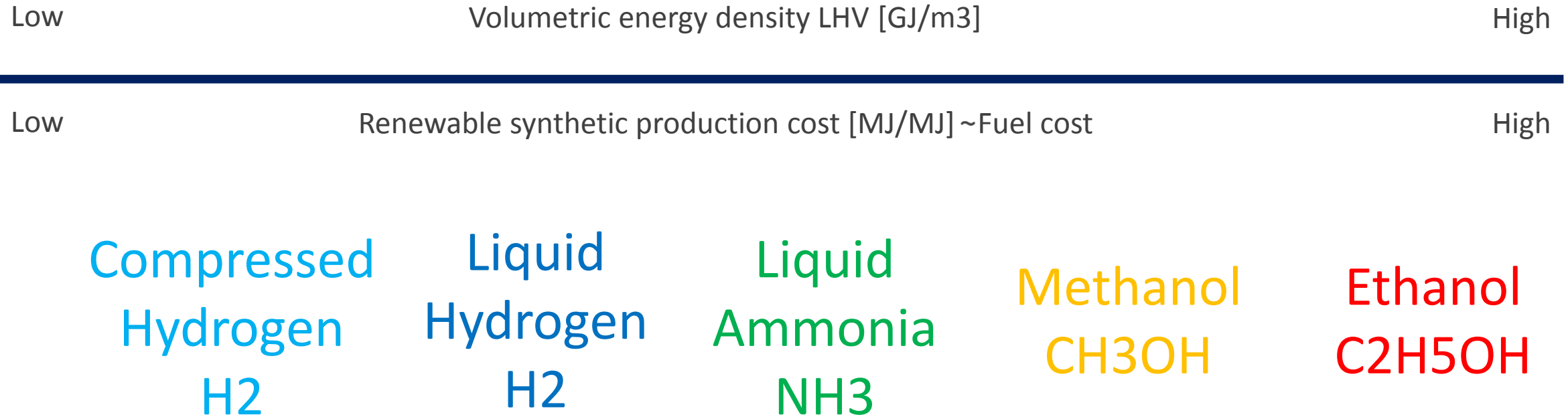
SHIP 2040



## Renewable Fuel Options

Low	Volumetric energy density LHV [GJ/m <sup>3</sup> ]	High
Low	Renewable synthetic production cost [MJ/MJ] ~Fuel cost	High

## Renewable Fuel Options



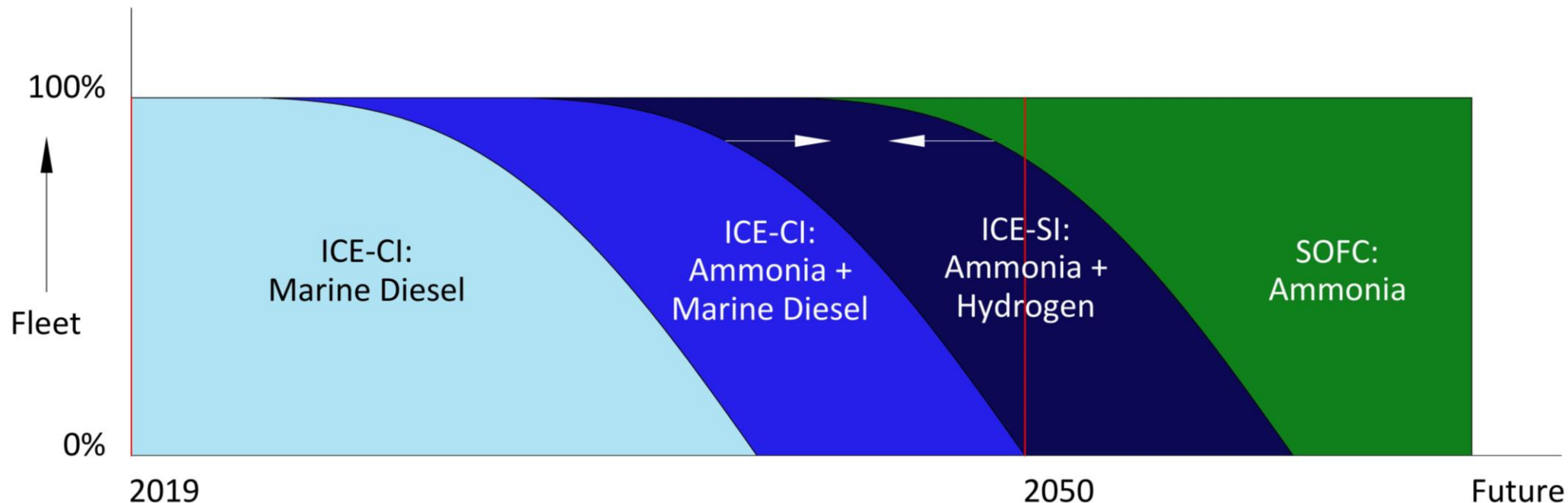
## Renewable Fuel Options

Fuel type:	Energy density LHV [MJ/kg]	Volumetric energy density LHV [GJ/m <sup>3</sup> ]	Renewable synthetic production cost [MJ/MJ]	Storage pressure [bar]	Storage temperature [°C]
Marine Gas Oil (reference)	42.8	36.6	Not applicable	1	20
Liquid Methane	50.0	23.4	2.3	1	-162
Ethanol	26.7	21.1	3.6	1	20
Methanol	19.9	15.8	2.6	1	20
Liquid Ammonia	18.6	12.7	1.8	1 or 10	-34 or 20
Liquid Hydrogen	120.0	8.5	1.8	1	-253
Compressed Hydrogen	120.0	7.5	1.7	700	20

- Ammonia balanced solution
  - Volumetric energy density
  - Renewable synthetic production cost



# Looking Back From 2050



ICE: Internal Combustion Engine  
CI: Compression Ignition  
SI: Spark Ignition  
SOFC: Solid Oxide Fuel Cell

Emission reduction			
CO <sub>2</sub>	>80%	100%	100%
NO <sub>x</sub>	0% (Apply SCR)	0% (Apply SCR)	100%
SO <sub>x</sub>	>80%	100%	100%
PM	>80%	100%	100%

SCR: Selective Catalytic Reduction  
Exhaust gas after treatment, capable  
of reducing NO<sub>x</sub> more than 95%

Time →



## Challenges of Ammonia

- Fuel Safety: Risk analysis vs Public perception

David Garman: “Ammonia isn’t sexy. It just works.”

David Garman, former Under Secretary of Energy, US Department of Energy The Curse of Shiny Objects, NH<sub>3</sub> Fuel Conference, 9/21/2015.

## Strenghts of Ammonia

- Stepwise technological implementation
- Ammonia production is easily scalable, and can be produced with the overcapacity of renewable energy with only water and air as resource
- Transition supported by existing infrastructure
- More than 100 years of industrial experience (Fertilizer, Cooling systems, DeNOx)
- Balanced solution:
  - Volumetric energy density
  - Renewable synthetic production cost





# Ammonia can Feed and Power the World







[www.c-job.com](http://www.c-job.com)

[info@c-job.com](mailto:info@c-job.com)

+31(0)880243700

Niels de Vries

[n.devries@c-job.com](mailto:n.devries@c-job.com)