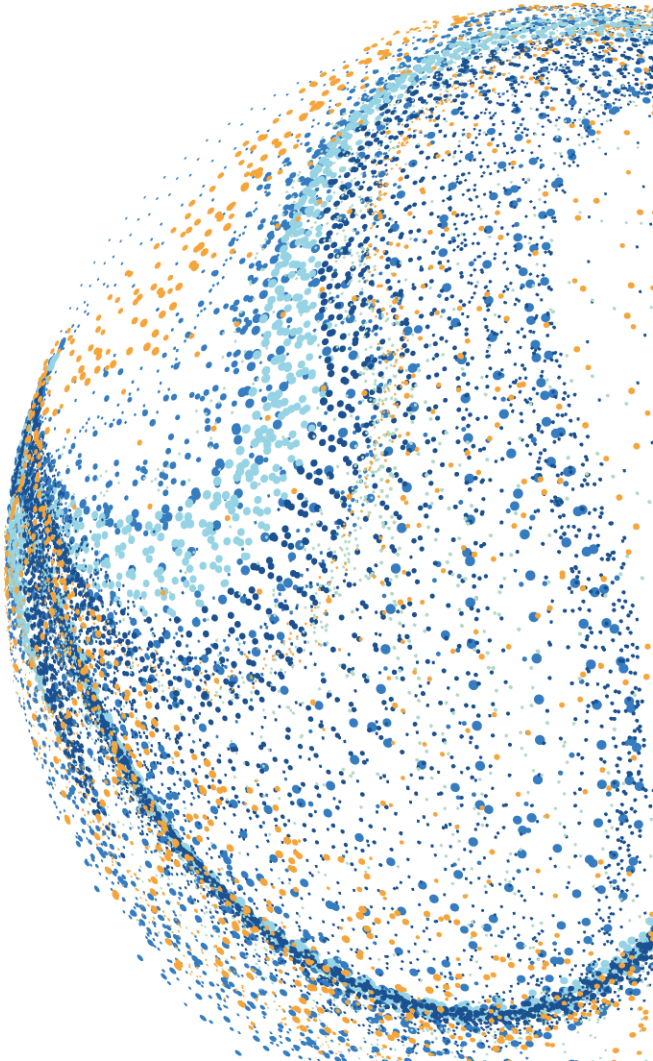
Wilhelmsen

Hydrogen as seen from a shipping company



H2@Ports Workshop

San Francisco, September 10 – 12, 2019

Per A. Brinchmann, Wilh. Wilhelmsen Holding ASA

A wise man said it like this:

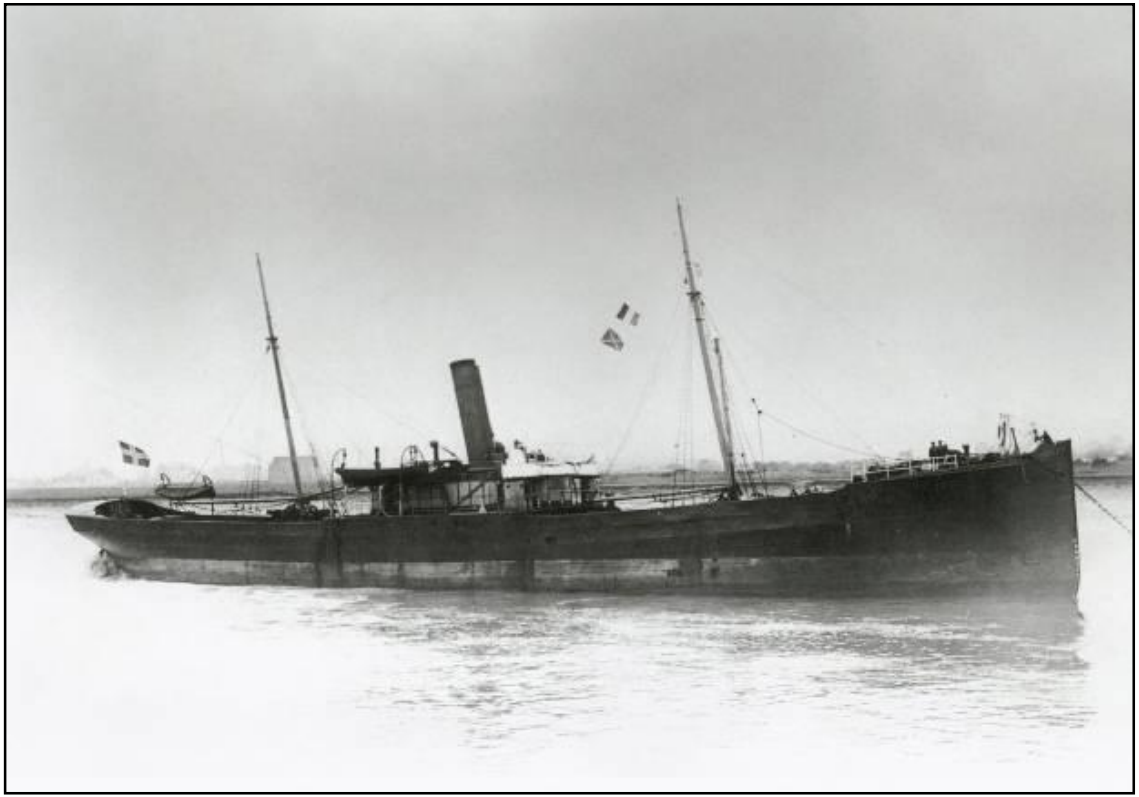
«The farther backward you can look,

the farther forward you are likely to see»

Sir Winston S. Churchill, 1874 - 1965

Our first non-emission vessel; Mathilde (1861 – 1880)

Our first polluter; steamship Talabot (1887 – 1905)



From wind to coal

−	+
Investment cost	Speed
Availability of coal	Regularity (year round)
Crew; number and competence	Safety
Technical complexity	Flexibility
Cargo capacity	Income

Enabled by technology, driven by economy, short sea first, took 50+ years

From coal to oil

-

Availability of oil

Bunkering systems

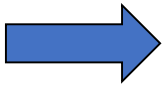
+

Crew; number and health

Cargo capacity

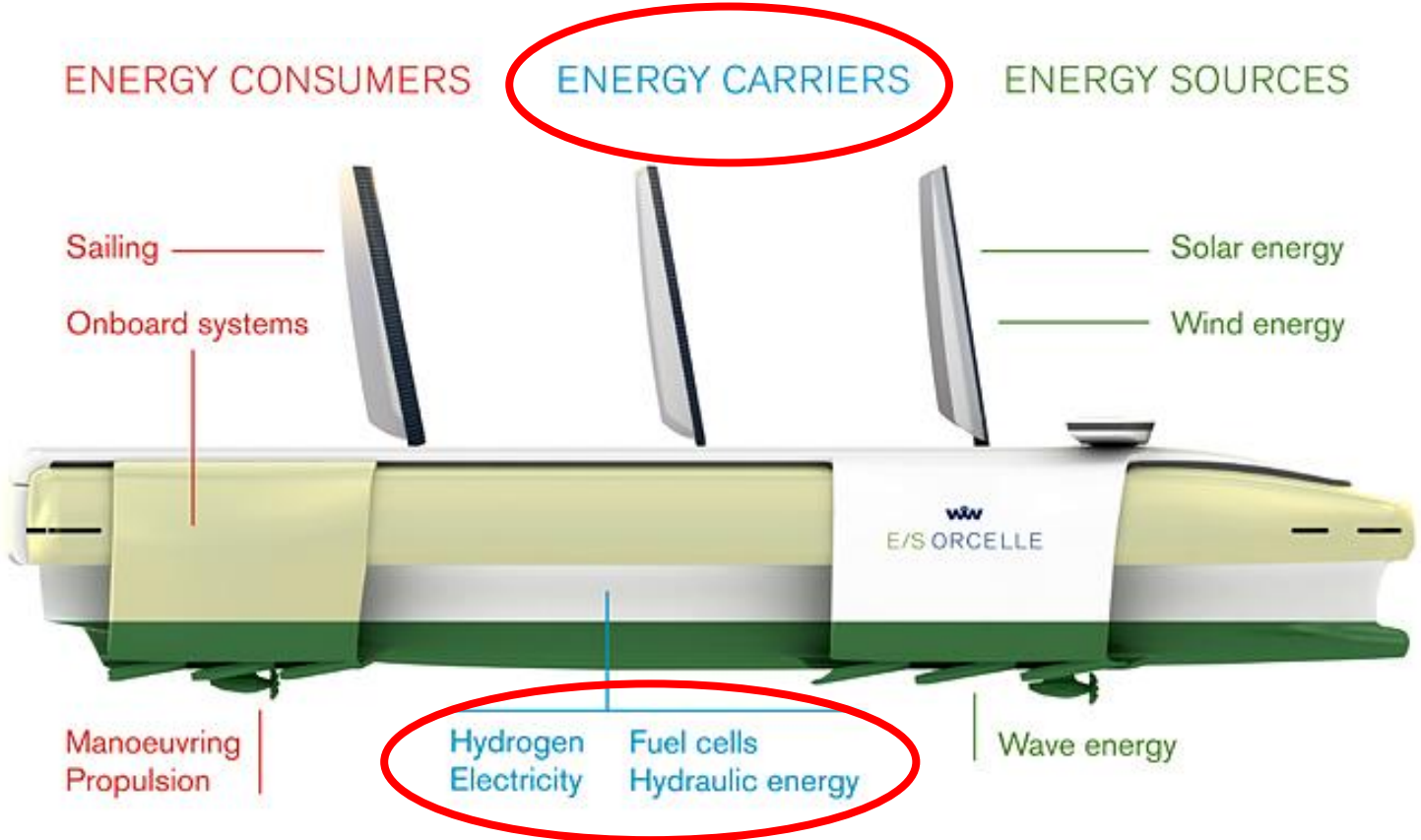
Endurance

Bunkering procedures



Enabled by technology, driven by economy, short sea first, took 30+ years

In 2005 we launched our vision for 2025, the Orcelle; a zero emission car carrier



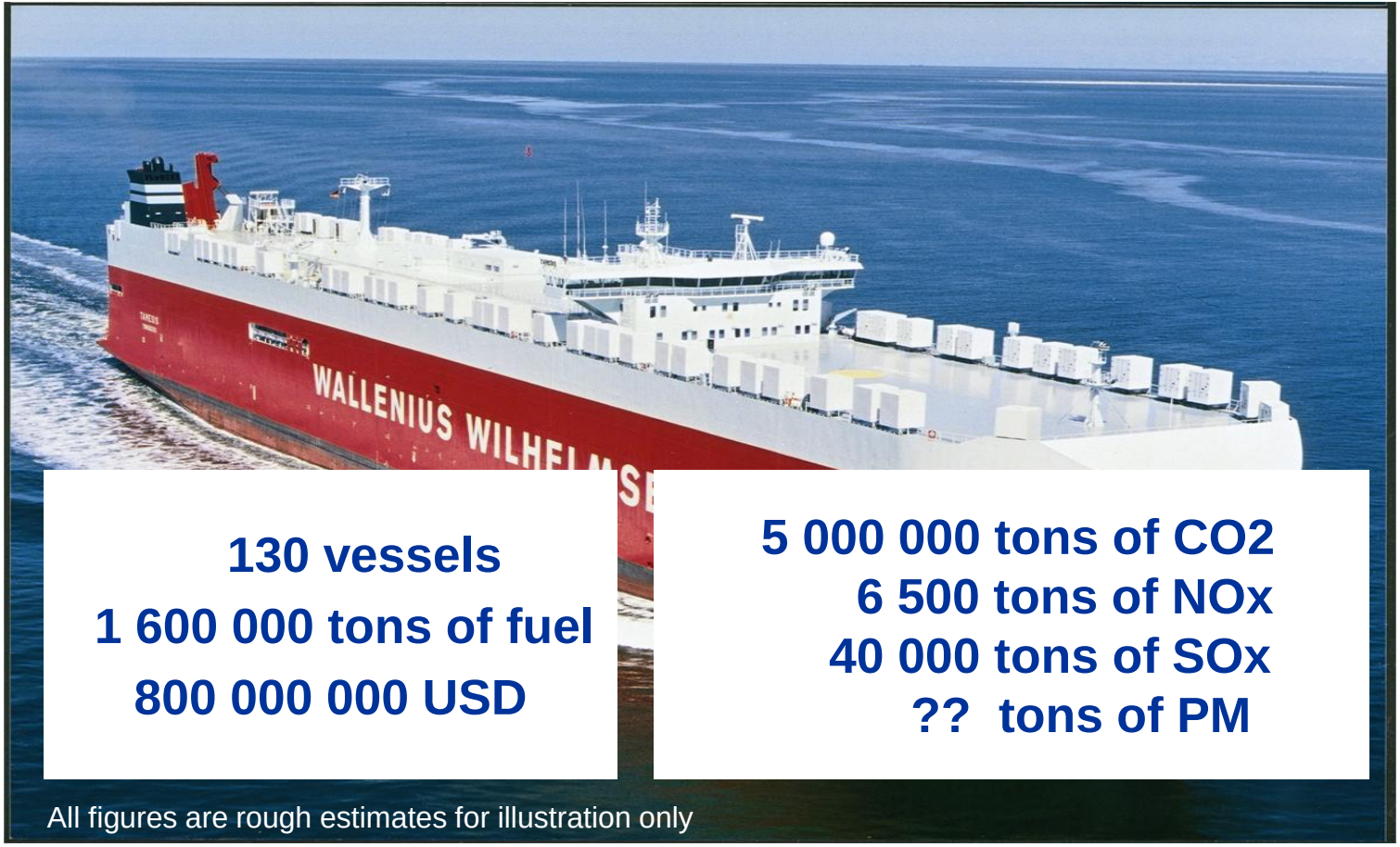
We participate in developing next generation vessels

The SeaShuttle project; a semi-autonomous container feeder with compressed hydrogen and fuel cells

Funded by the Norwegian Government

We initiated design of the first LH2 bunker vessel; BV Tomorrow

Example of today's emission challenges in shipping

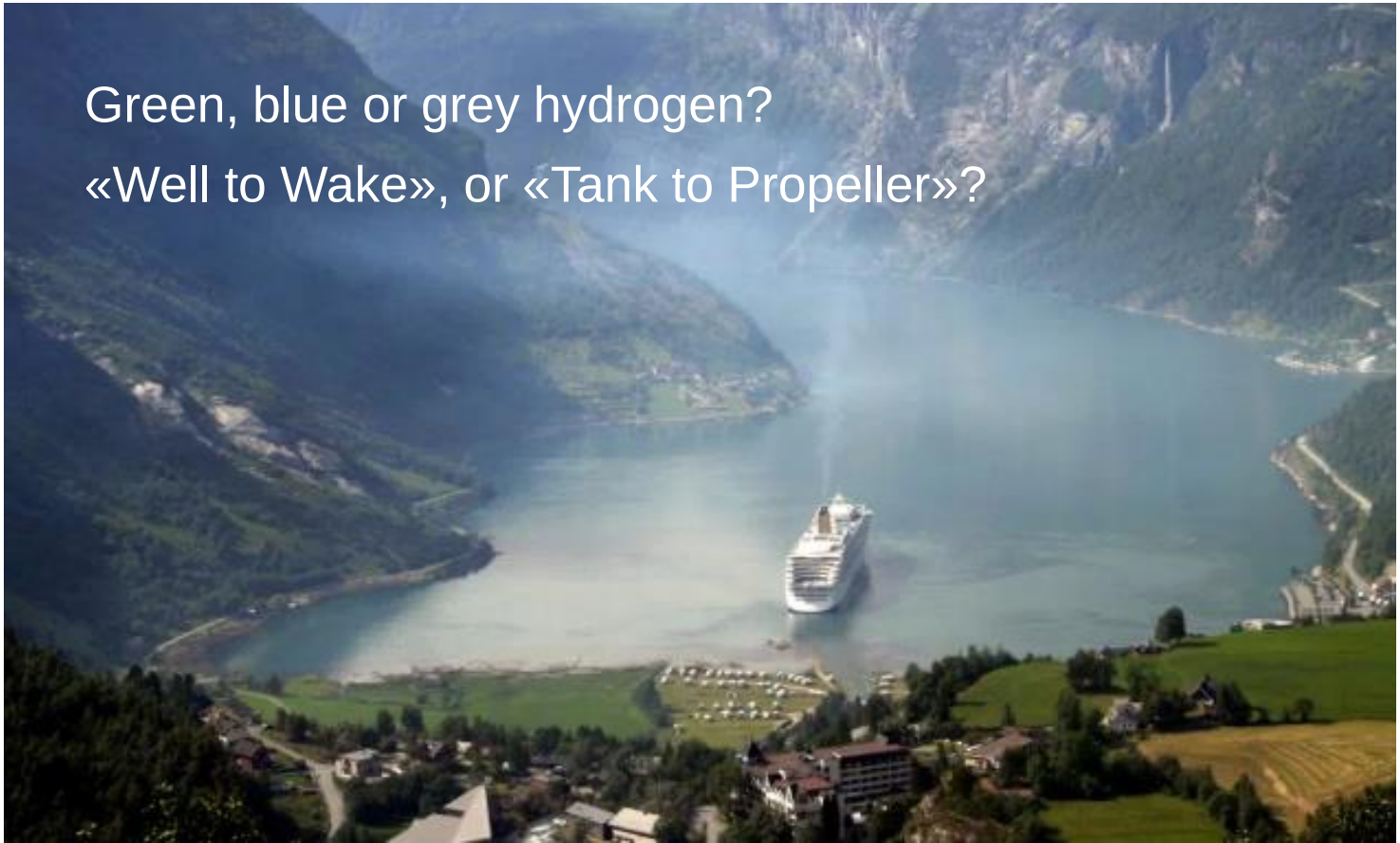


130 vessels
1 600 000 tons of fuel
800 000 000 USD

5 000 000 tons of CO2
6 500 tons of NOx
40 000 tons of SOx
?? tons of PM

All figures are rough estimates for illustration only

What is global climate related, and what is local pollution?



Lack of regulatory framework; a showstopper?

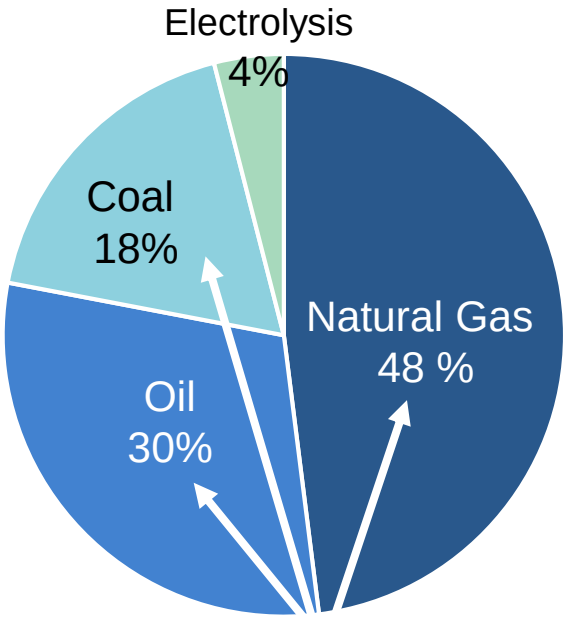
Regulative status hydrogen and fuel cells		
	IMO	
Fuel cell installations	• No Regulations existing • Development ongoing, but proces… slow. • IGF code Pa…	…escriptive …launched Jan 1st 2018. This is prescriptive rules with detailed req's.
…distribution	…Regulations existing • IGF code Part A require Alternative Design Approach to be followed (i.e. IMO MSC.1/1455)	• No Rules existing • Will follow IMO pathway

The Norwegian Maritime Cluster pioneered the shifts to LNG and Batteries, now we are full ahead on Autonomy and Hydrogen!

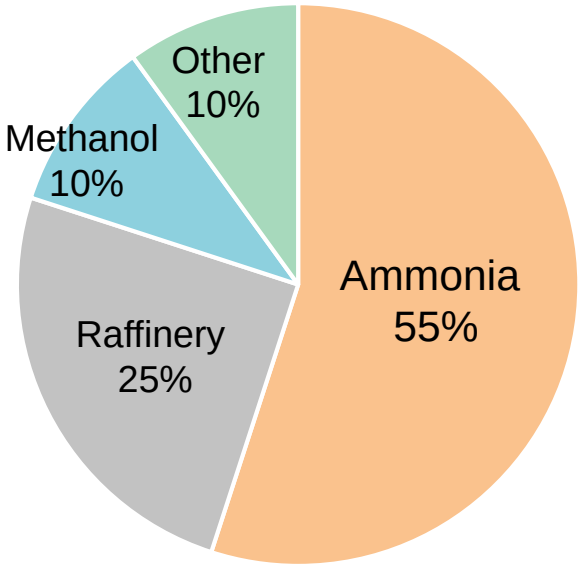
Source; HYON

World production and use of Hydrogen (~70 mill. tons/y)

Production sources

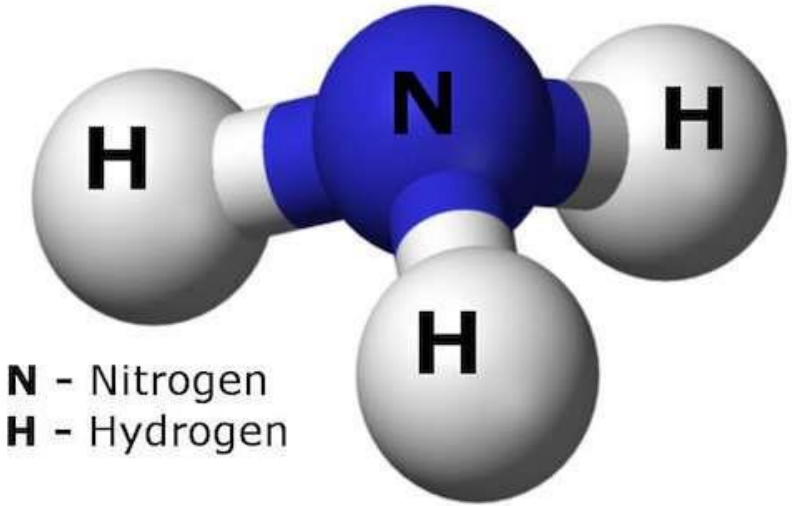


Use: 90% in process industry



Main challenge: CO2 emissions

Ammonia; NH3, another way of handling hydrogen



Processed from hydrogen and nitrogen

To be stored and transported liquid when
- cooled to minus 33 C or
- compressed to 9 bars

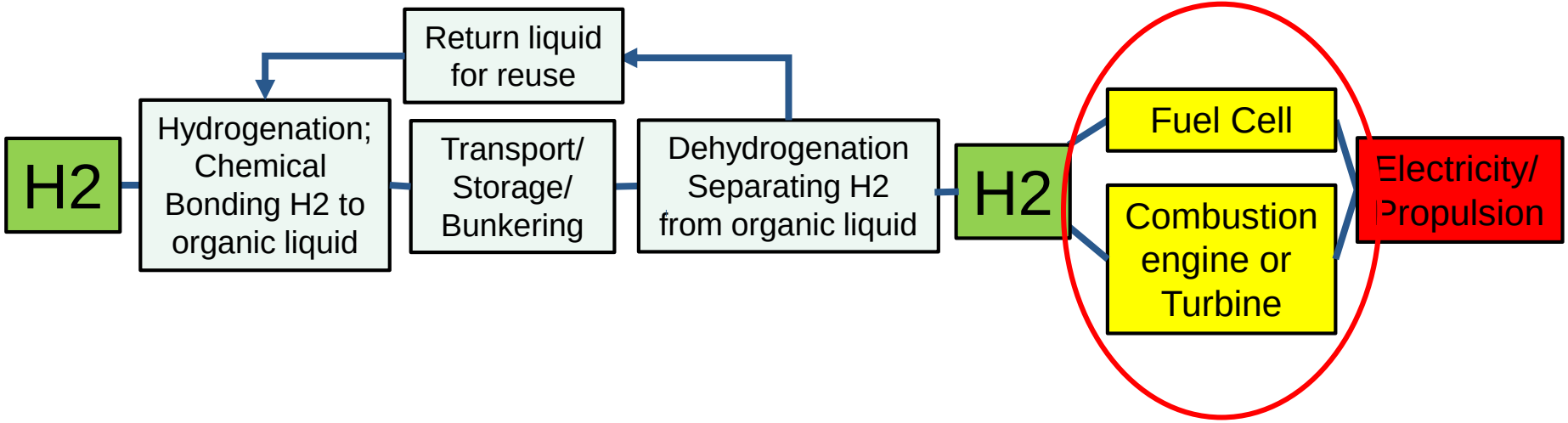
A commodity well known as cargo

May be used in combustion engines:
emits no CO2, but NOx (to be removed by SCR)

BUT: What does the Chief say?

Liquid Organic Hydrogen Carrier; LOHC

New technology under development



To be handled like oil in tanks, pumps and pipes
Carries 57 kgs H2 per m3

Ref: https://www.hydrogenious.net/index.php/en/hydrogen-2-2/

We consider these 4 hydrogen fuels as our options

No solution fits all, and we may still find new ones

Compressed; CH2	Liquid; LH2	Ammonia; NH3	LOHC
Ferries and high speed craft Short sea cargo vessels	Ferries and high speed craft Short sea cargo vessels Offshore vessels Cruise vessels	Short and deep sea cargo vessels Offshore vessels Retrofit in general	Short sea cargo vessels in fixed routes

Common challenges in all hydrogen valuechains: Overall energy efficiency <25%!!

Some considerations on way forward

To authorities:

- Do not specify technologies, but set realistic goals and requirements to emissions
- Be predictable in regulatory matters
- Help forerunners in risk mitigation (funding, research, long term contracts)
- This is a volume game; accept grey hydrogen to get moving

To technology providers:

- Think wide in your choice of solutions
- Be open on all your pros and cons and challenges

From oil to hydrogen?

–

Investment cost
Cargo capacity / Endurance
Crew; competence
Availability and price of fuel
Safety issues
Bunkering systems

+

Environmental impact
Less maintenance (?)
Cleaner on board

→ To be enabled by technology, must be driven by economy, short sea first, will take 10 years?

Good luck to us all!

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