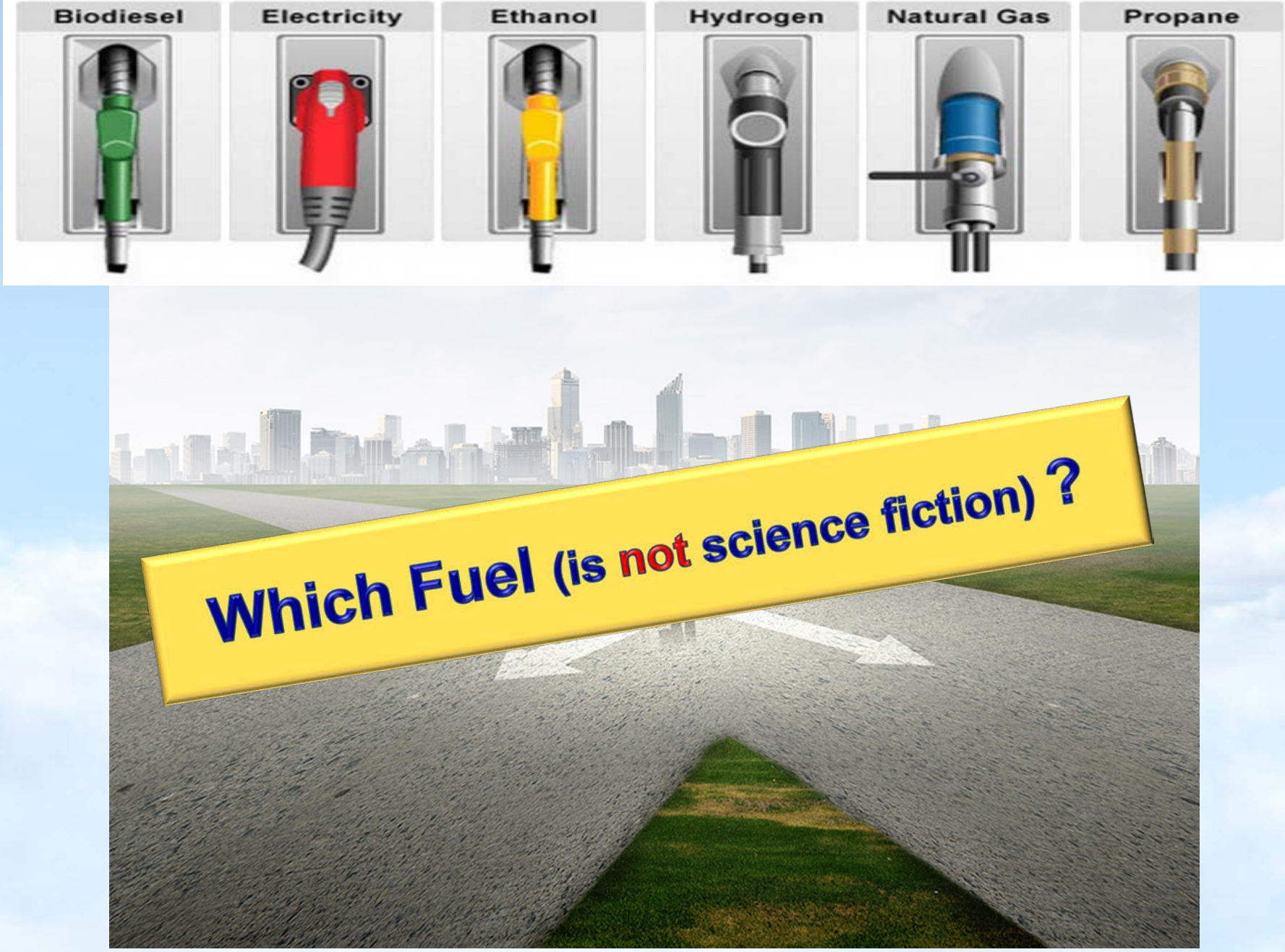

Biodiesel
Electricity
Ethanol
Hydrogen
Natural Gas
Propane
Which Fuel (is not science fiction) ?

Alternative fuels

x 3-4

NG

55 kWh/kg

49 kg CO2 / kg

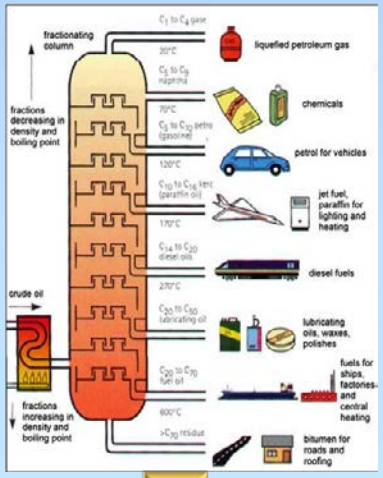
95% of world productio

x 10-15

Hydrogen

9 – 12 kg CO2 / kg

1 – 5 %



LPG

(propane/butane)

x 3

Ammonia

x 2.3

Methanol

Biofuels

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Alternative fuels

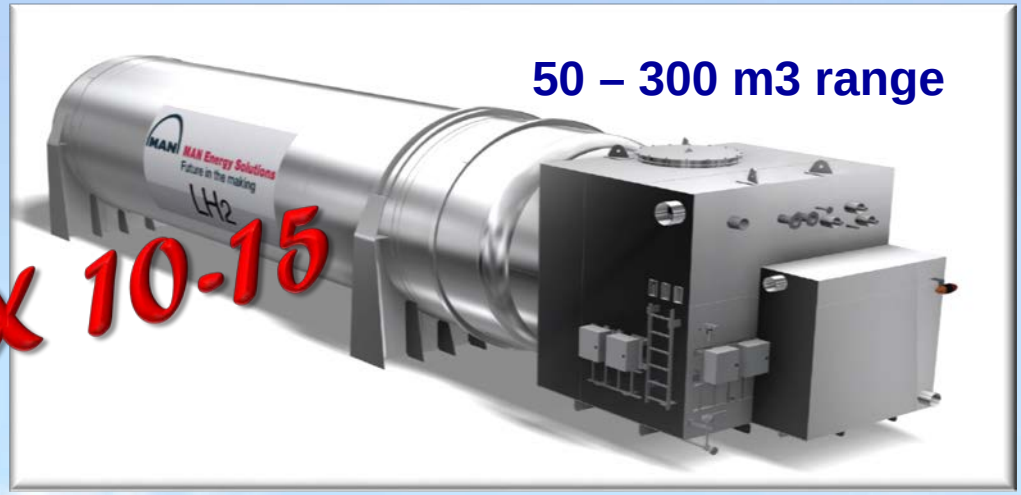
Hydrogen

- No bunkering vessels or terminals (only Trucks)
- Needs -253 Deg C
- Explosive
- Colorless, odorless, not visible flame
- Tendency to leak at joints
- Reaction with metals (metal embrittlement)
- Regulatory framework yet to be established.

MAN

Alternative fuels

Hydrogen



- No more than 69% full, no less than 5%
- Empty tank weight for a 175 m3 = 70 tons.
- This gives a usable volume of 64%. 300x.64= 192 / 12 = 16 mt of Diesel.
- For one day sailing of a supra you need 2 of these. For 10 days, 20, etc.
- Maybe good for small ships and fuel cells.

MAN

Alternative fuels

Ammonia

- Needs – 34 Deg C.
- Releases NOx when burned.
- Explosive between 15 – 33%.
- Attacks most metals.
- Highly toxic. (PPE) 0.7‰ = Deadly
- Water-seeking chemical. Forms gas cloud.
- Environmental Disaster if spilled. One spill = cubic miles of sterilized sea. 1ppm in water kills Marine life.

MAN

- Value of existing Bunkering Infrastructure: $ 2.5 trillion
- Value of all existing Ships: $ 1 trillion
- Throw these away and replace at a cost of $ 5.5 Trillion?
- Is there a green fuel that can use existing infrastructure and ship engines?

YES

Alternative fuels

55 kWh/kg

Hydrogen

Methanol + H_2O

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Alternative fuels

Methanol

- Needs – 34 Deg C.
- Releases NOx when burned.
- Explosive between 15 – 38%.
- Highly toxic. (PPE) 0.7‰ = Deadly
- Water-seeking chemical. Forms gas cloud.
- Environmental Disaster if spilled. One spill = cubic miles of sterilized sea. 1ppm in water kills Marine life.

MAN

Alternative fuels

Methanol

- It’s like Diesel (only better)
- No problem to the environment when spilled !

▼ Table 2: Indicative comparison of HAZID risk rankings

Intolerable risk | Tolerable risk - ALARP | Broadly acceptable

Node	What If Questions	Causes	Consequences	LNG	H2	Ammonia	Methanol
1. Navigation	What if there is loss of manoeuvrability at sea?	1. Propulsion failure	1. Grounding	C1-L4	C1-L4	C1-L4	C1-L4
			2. Collision	C1-L4	C1-L4	C1-L4	C1-L4
			3. Build-up of tank pressure	C1-L5	C1-L5	C3-L3	C1-L1
			4. Excess motions	C1-L5	C1-L5	C1-L5	C1-L1
	What if there are excessive motions at sea?	1. Loss of fin stabilisers	1. Excess motions	C1-L5	C1-L5	C1-L5	C1-L1
	What if there is a black-out at sea?	1. Engine / generator failures	1. Boil-off management affected that could lead to build-up in tank pressure	C1-L2	C1-L2	C2-L2	C1-L1
	What if an excessive trim / list develops at sea or in port?	1. Loading / Ballasting error	1. Potential for gas pocket formation	C1-L2	C1-L2	C3-L2	C1-L1
		2. Grounding	1. Large heel / trim angles that could lead to liquid fuel coming from vent mast	C1-L2	C1-L2	C5-L3	C1-L1
		3. Collision leading to hull breach	1. Large heel / trim angles that could lead to liquid fuel coming from vent mast	C1-L3	C1-L3	C5-L3	C1-L1
	What if there is a requirement for tug support / 3rd party vessel attendance at sea or in port?	1. Fuel / Bunker / Supply up lift	1. Potential source of ignition	C3-L2	C3-L3	C1-L1	C3-L2
			2. Damage to pipe work (hard landing / hard contact by tug)	C1-L2	C1-L2	C1-L2	C1-L2
			3. Potential of exposure to toxic fumes	-	-	C3-L2	-
	What if there is a ship grounding in way of the future fuel tanks and system?	1. Propulsion / steering gear / human failure	1. Tank breach	C5-L1	C5-L1	C5-L1	C2-L3
	What if the vessel needs to be abandoned?	1. Loss of LNG tank pressure control / LNG tank breach / Loss of propulsion in high seas that pose risk to crew	1. Liquid / vapour release / Tank pressure build up	C1-L1	C3-L2	C1-L1	C1-L1
2. External events	What if there is a ship collision in way of the fuel tanks?	1. Hull breach	1. Loss of containment	C5-L1	C5-L1	C5-L1	C2-L3
			2. Build-up of tank pressure	C1-L2	C1-L2	C1-L2	
			3. Potential ignition sources in hazardous areas (from colliding vessel)	C3-L2	C3-L2	C3-L2	C3-L2
	Potential of ignition	1. Oil spill / pipe breach / vehicle fire / lightning strike / etc.	1. Build-up of tank pressure	C1-L2	C2-L3	C3-L2	C1-L1
3. Ship operations other than bunkering	What if cargo operations are required in way of the future fuel tanks and system components?	1. Operational requirements	1. Damage to equipment / Vent mast	C1-L5	C1-L5	C3-L5	C1-L4
		2. Crane reach	1. Inadvertent ignition source in hazardous area		C2-L4		
	What if there is a crew change?	1. Operational requirements	1. Potential for un/under-informed personnel taking over control	C1-L1	C1-L1	C1-L1	C1-L1
	What if there is a completely new crew after vessel handover?	1. Crew unfamiliar with the vessel	1. Potential for un/under-informed personnel taking over control	C1-L5	C2-L5	C2-L5	C1-L2

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