METHANOL INSTITUTE

Renewable methanol Trends and developments

IEA EGRD

Eelco Dekker, Chief EU Representative, Methanol Institute

Paris, October 21, 2019

01 Introduction

A global industry association

- First formed in 1989, the Methanol Institute (MI) serves as the trade association for the global methanol industry.

- MI represents the world's leading methanol producers, distributors and technology companies from offices around the world



MI provides value to its members by:

- Ensuring safe handling of methanol and its derivatives
- Promoting methanol growth by furthering methanol as an essential chemical commodity and an emerging source of clean and renewable energy
- Influencing global regulatory and public policy initiatives that impact the methanol industry

2019 members



Methanol is simplest of alcohols

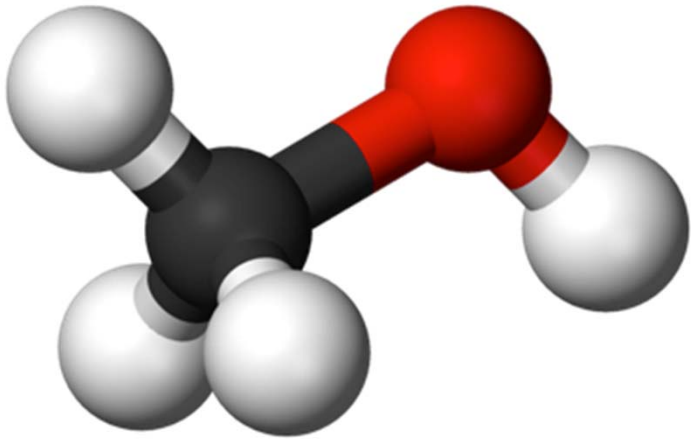
- Simple molecule rich in hydrogen, with only a single carbon bond
- Clear and colorless liquid at room temperature and ambient pressure
- Also known as “wood alcohol,” methanol can be produced from a wide range of feedstocks

Formula: CH_3OH

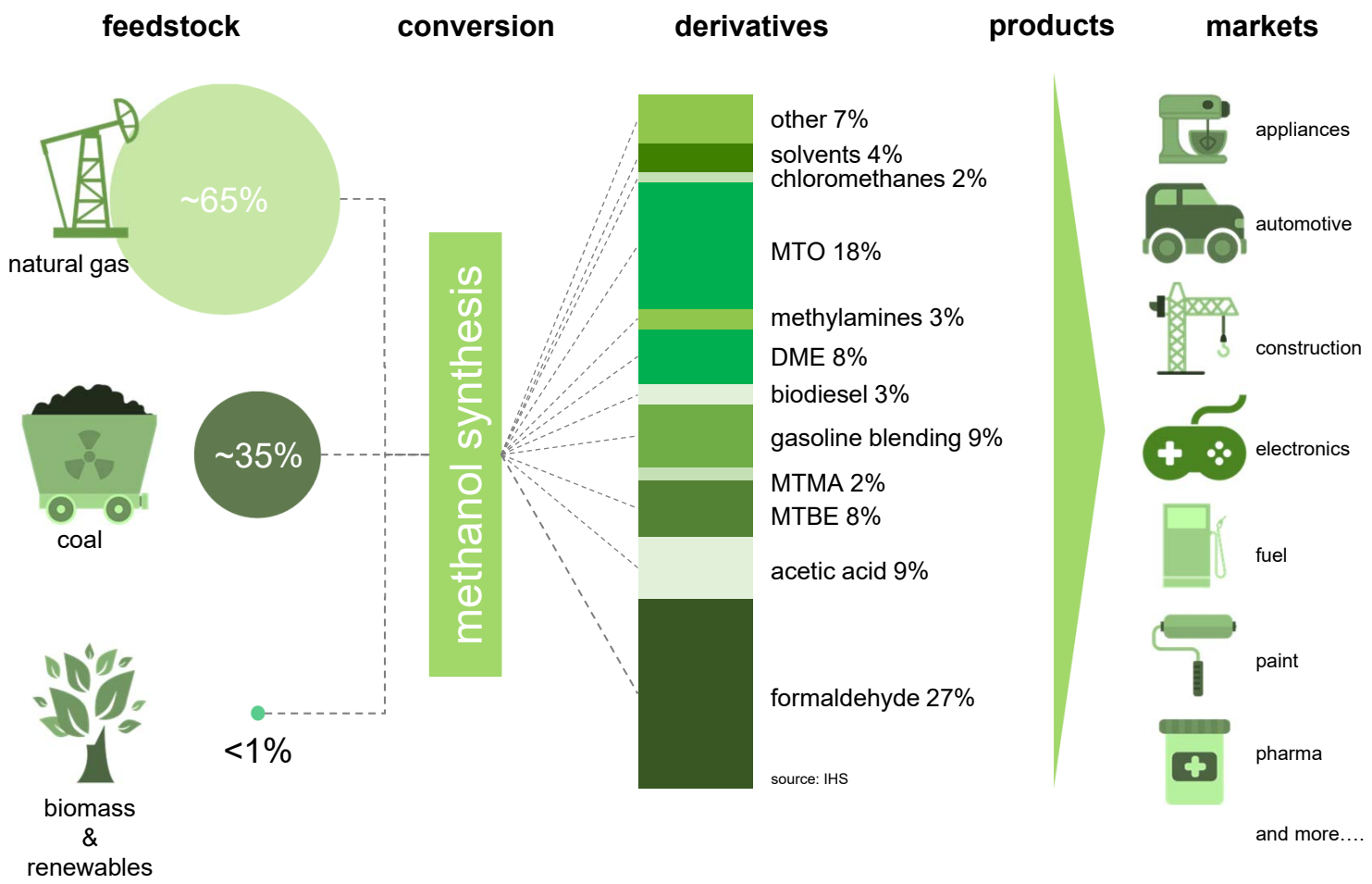
Density: 0,792 $g.cm^{-3}$

Molar mass: 32,04 $g\ mol^{-1}$

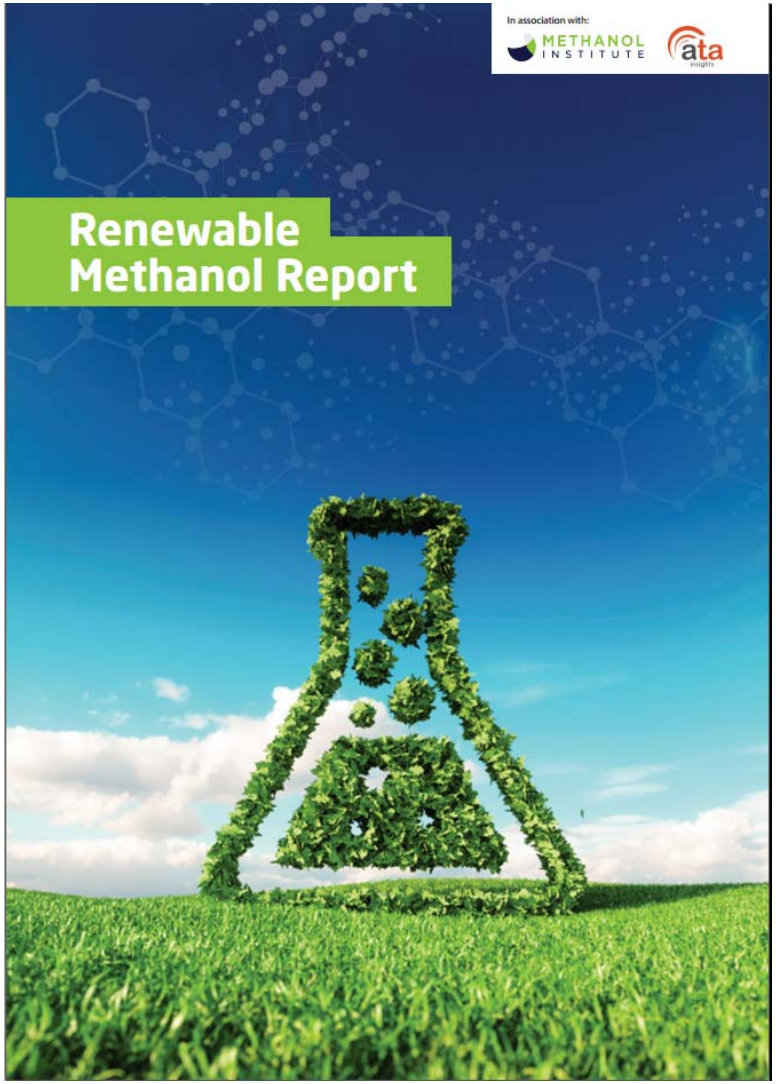
Appearance: colourless liquid



Broad feedstock range, many applications



Renewable methanol report available



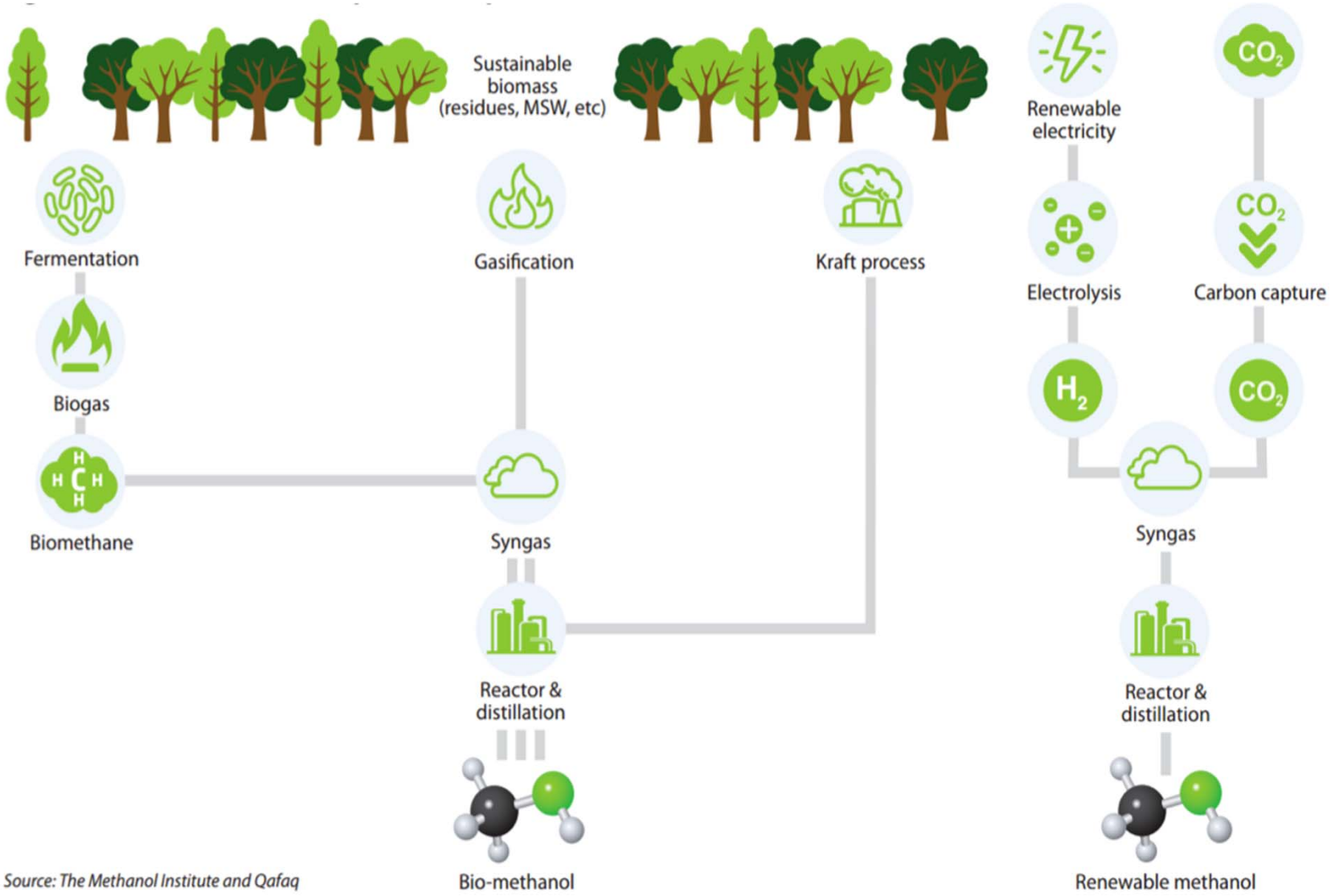
In February 2019 MI released its ***Renewable Methanol Report*** prepared by ATA Insights

Contents:

- Executive summary
- Why consider renewable methanol?
- Renewable methanol production
- Case Studies: CRI, Enerkem, BioMCN
- Applications and uses of renewable methanol
- Conclusions and how to find out more

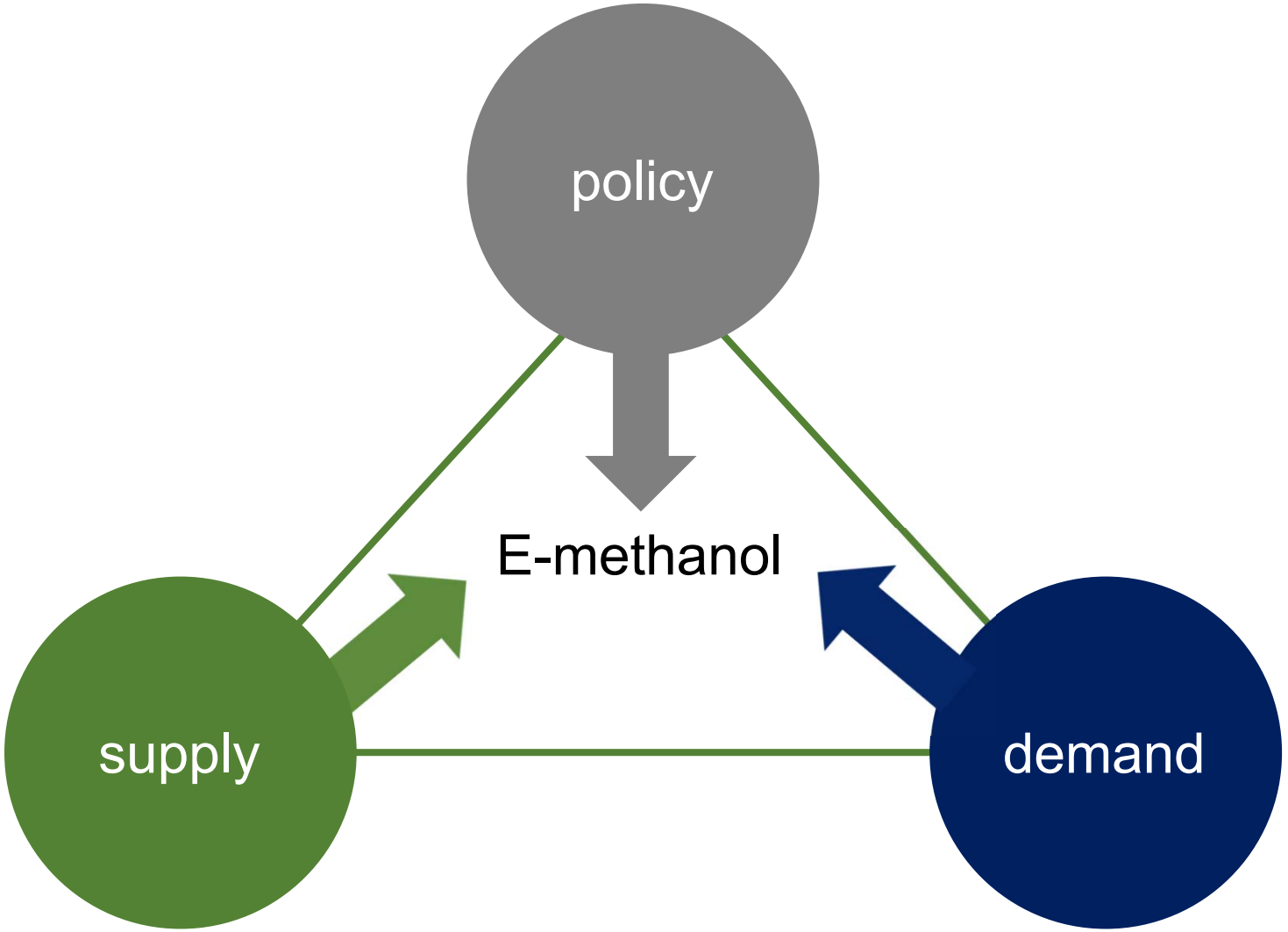
- https://www.methanol.org/renewable-methanol/

Low carbon pathways exist



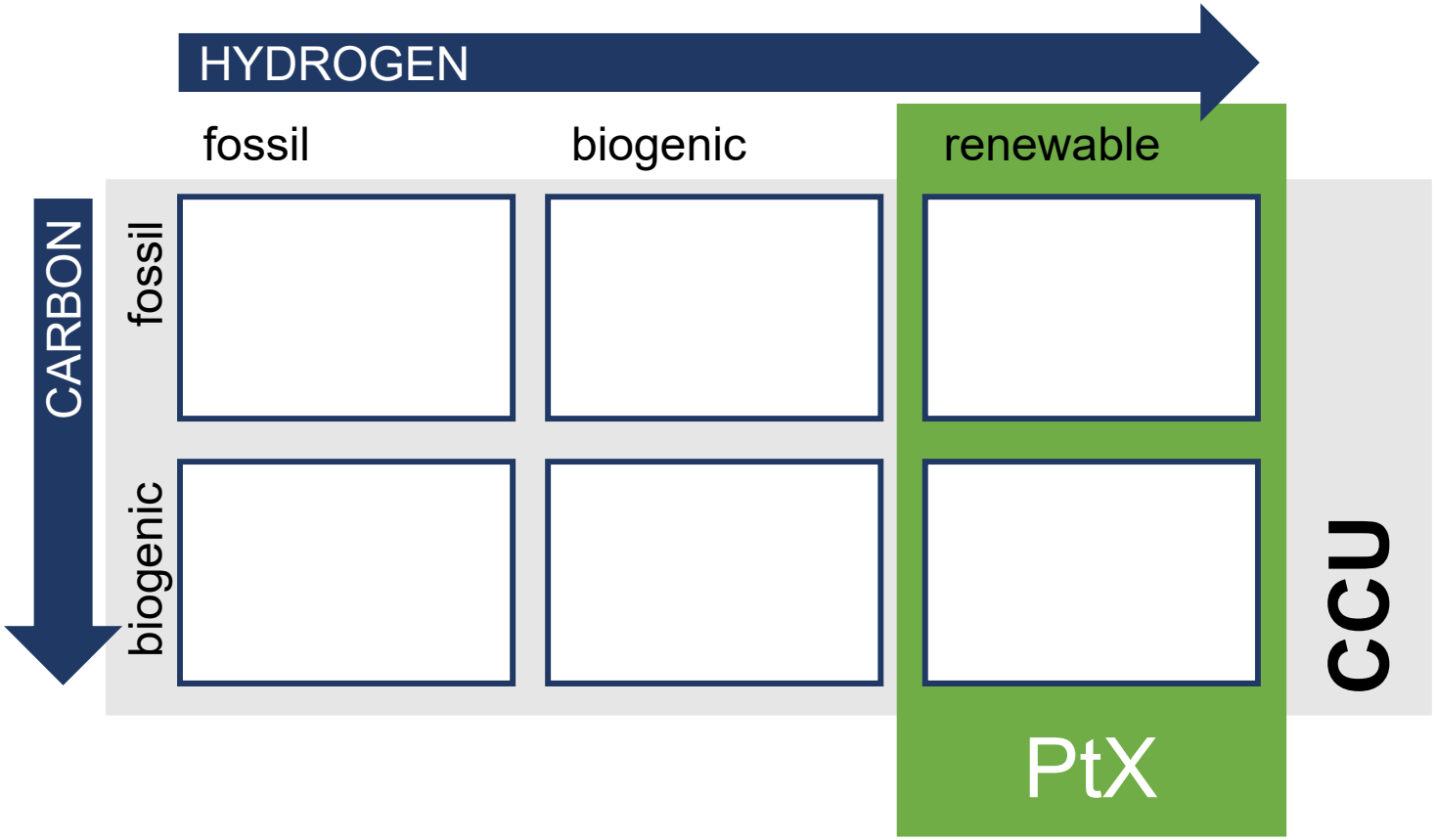
Source: The Methanol Institute and Qafaq

Different forces impact e-methanol potential



02 Supply

PtX and CCU are similar, but different



Plenty of sources of CO_2 available



Direct Air Capture
Concentration ~415 ppm



Flue gases up to 700 ton/hour
Concentration ~10% - 15%



Ethanol fermentation up to 50 ton/hour
Concentration ~95%



Biogas purification up to 0,7 ton/hour
Concentration ~90%

Increasing carbon conversion yield



Gevo

Ethanol production

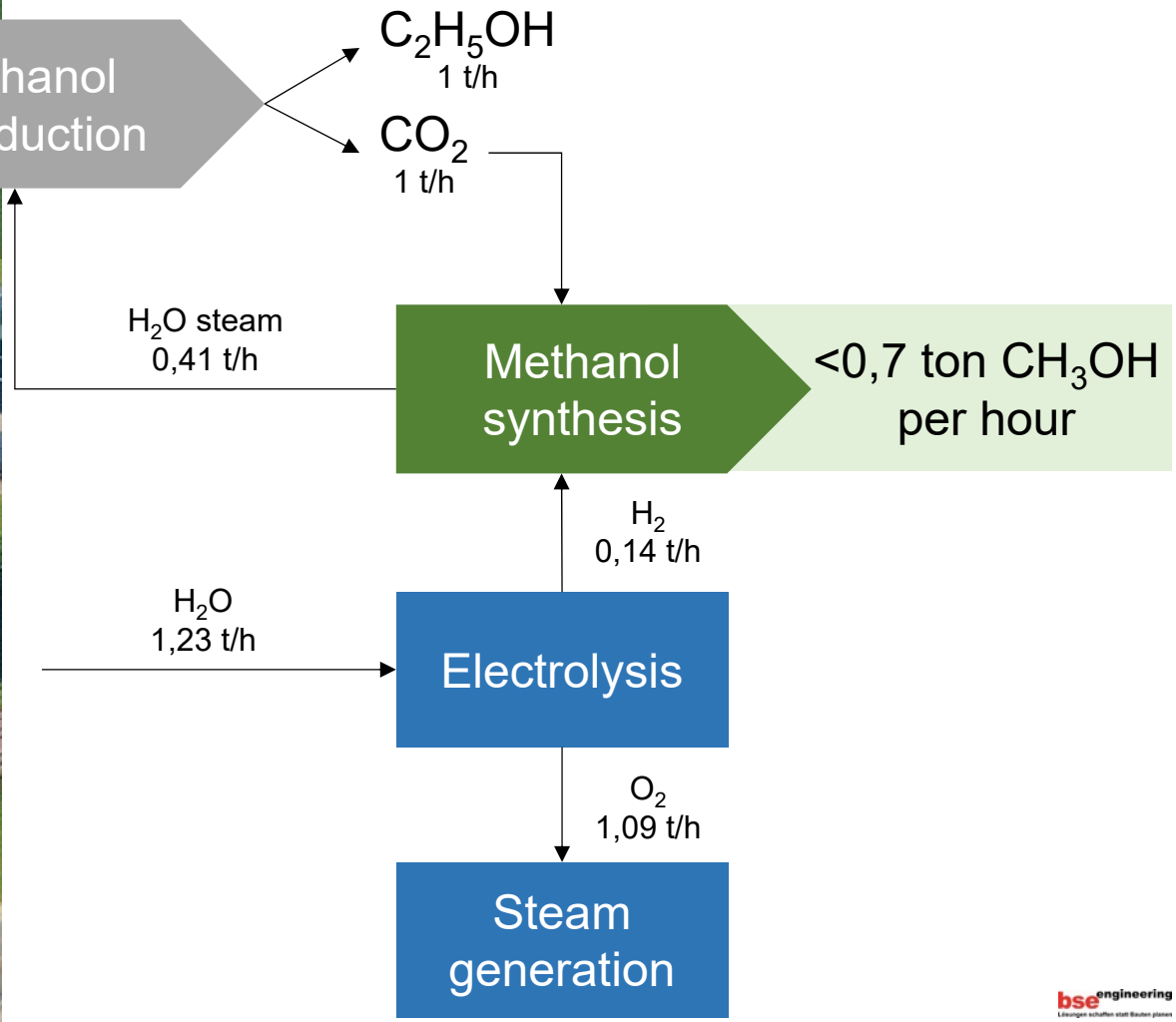
C_2H_5OH
1 t/h

CO_2
1 t/h

Increasing carbon conversion yield

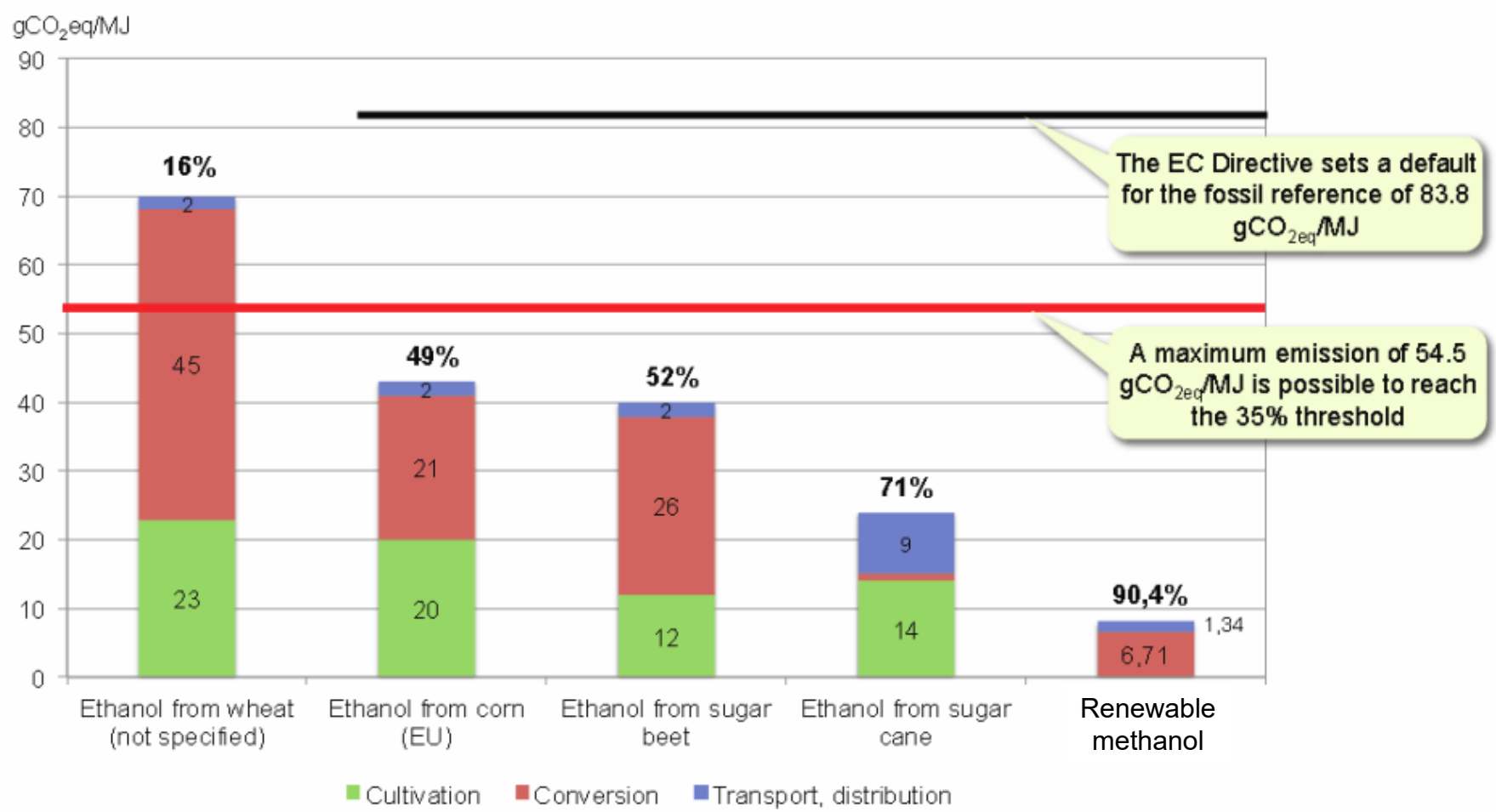


Gevo



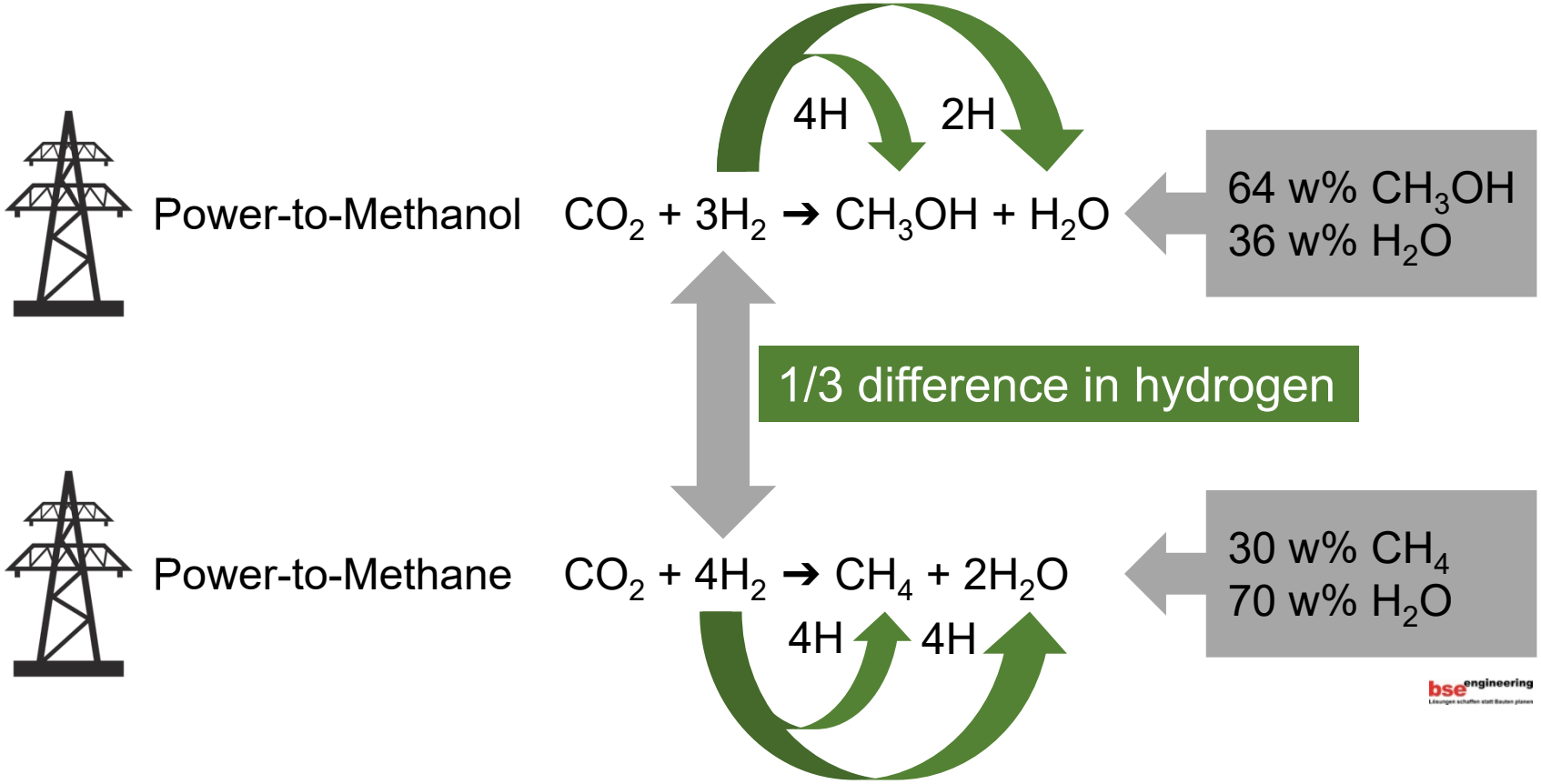
bse engineering

Very low carbon intensity and no (i)LUC



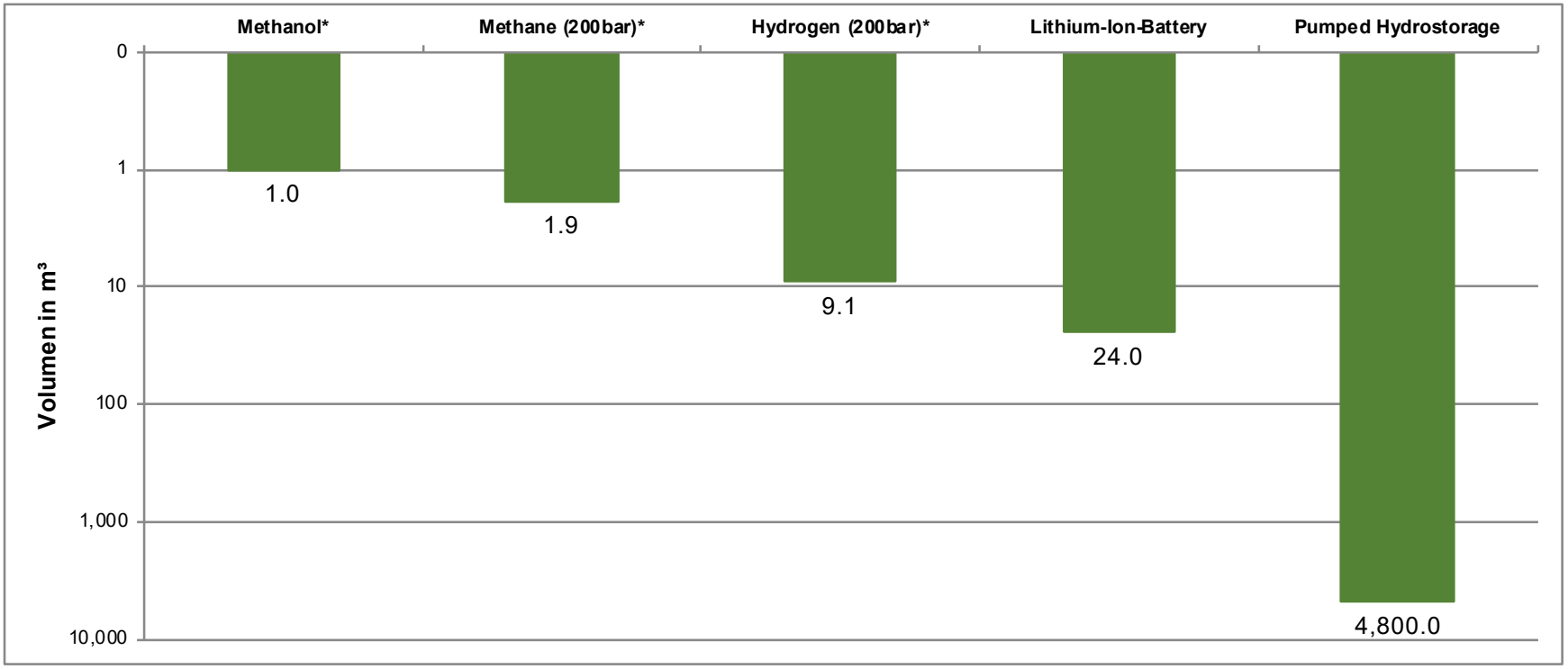
Source: Meo Carbon Solutions

Methanol process requires less hydrogen



Methanol has a density advantage

To store 4.800 kWh requires very different volumes:



*Calculation excluding conversion losses based on heating value

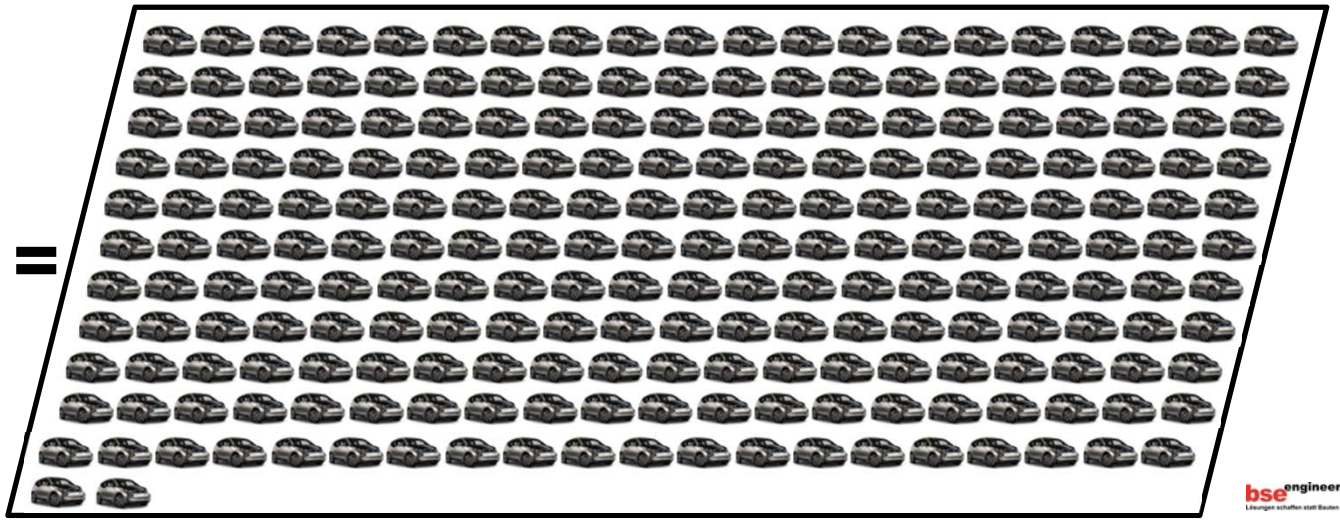
The practical side of energy storage

One cubic meter of e-Methanol contains the same amount of energy as the battery capacity of **222** BMW i3‘s*



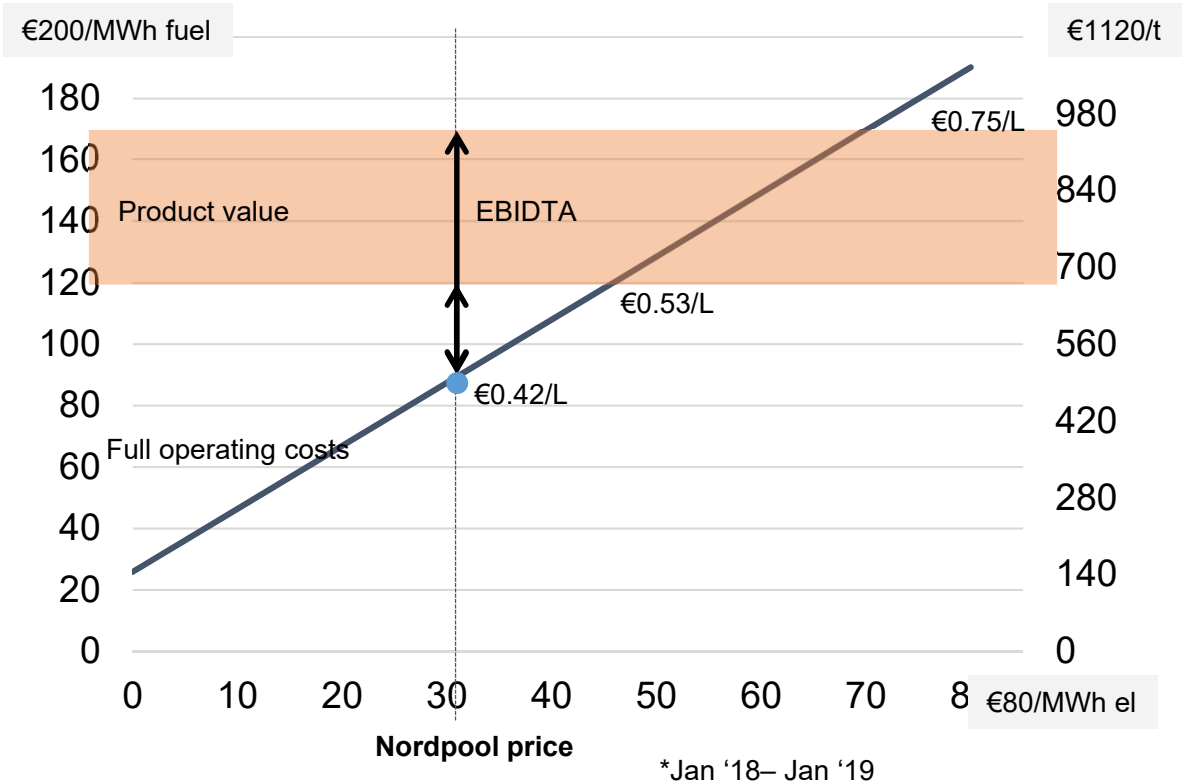
1 Nm³ CH_3OH

=



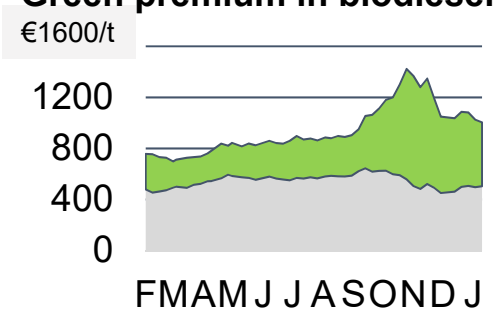
*Storage capacity BMW i3 = 21,6 kWh

Competitive cost position feasible

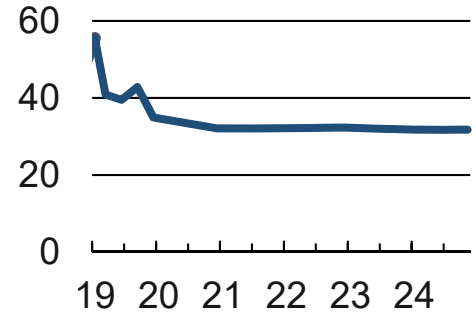


*Jan '18– Jan '19
Sources: CRI, NasdaqOMX, Energy Census

Green premium in biodiesel



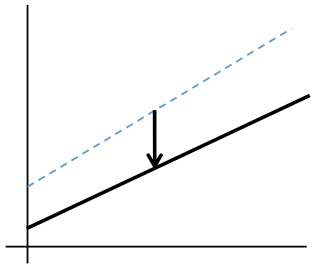
Nordpool electricity futures



Source: CARBON RECYCLING INTERNATIONAL

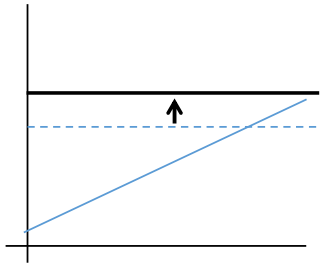
Several factors impact profitability

Economics improving



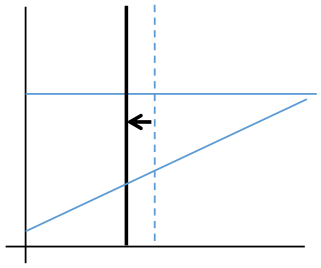
Learning curve effects
Scale economies
Efficiency improvements

Growing renewable fuel demand



Increasing targets
Cap on biofuels
Battery electric drive not applied in trucks or ships

Increased low-cost RES electricity



Wind and PV costs falling
Intermittency = surplus capacity
Grid congestion

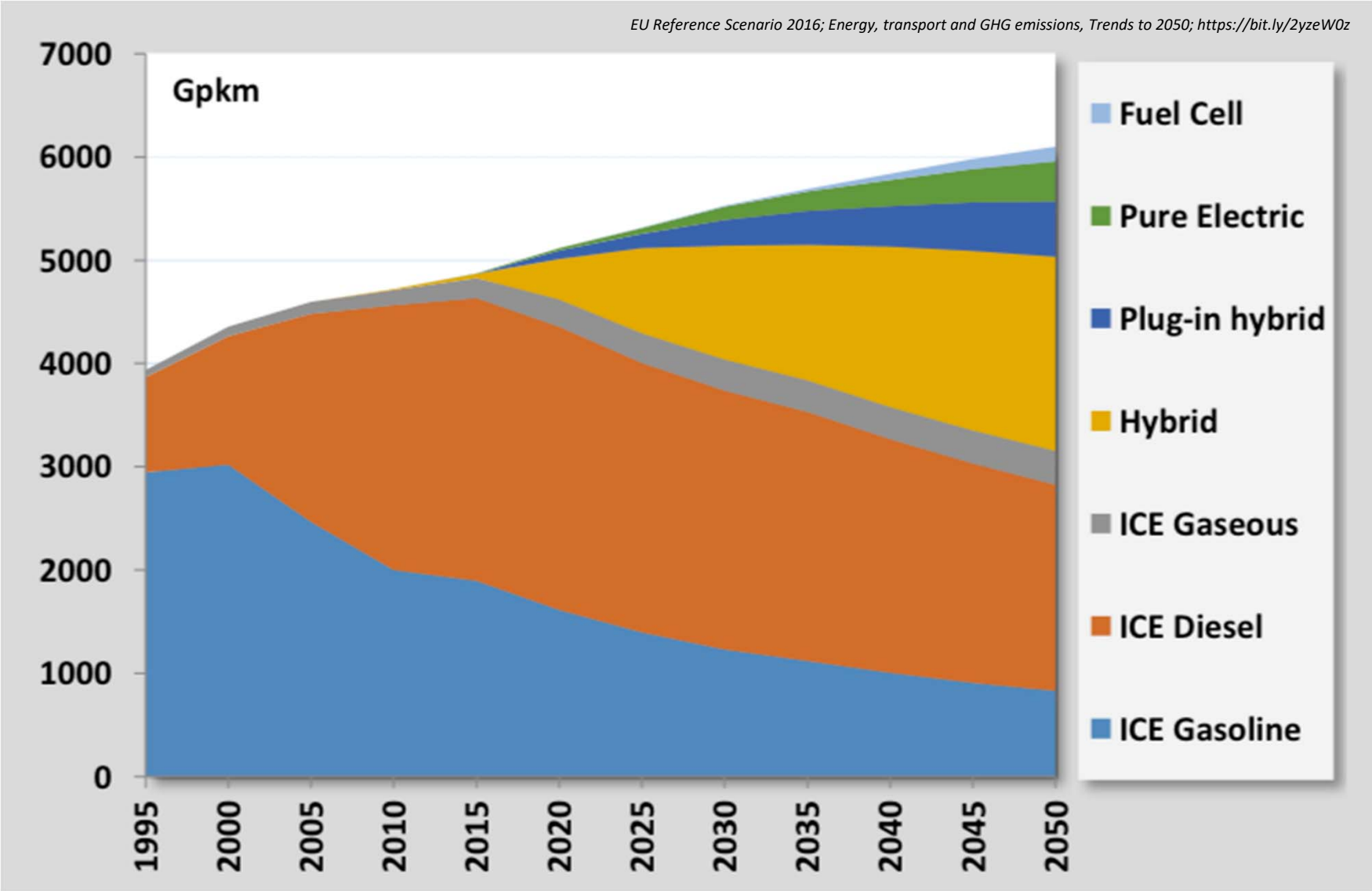
Most e-methanol examples in Europe



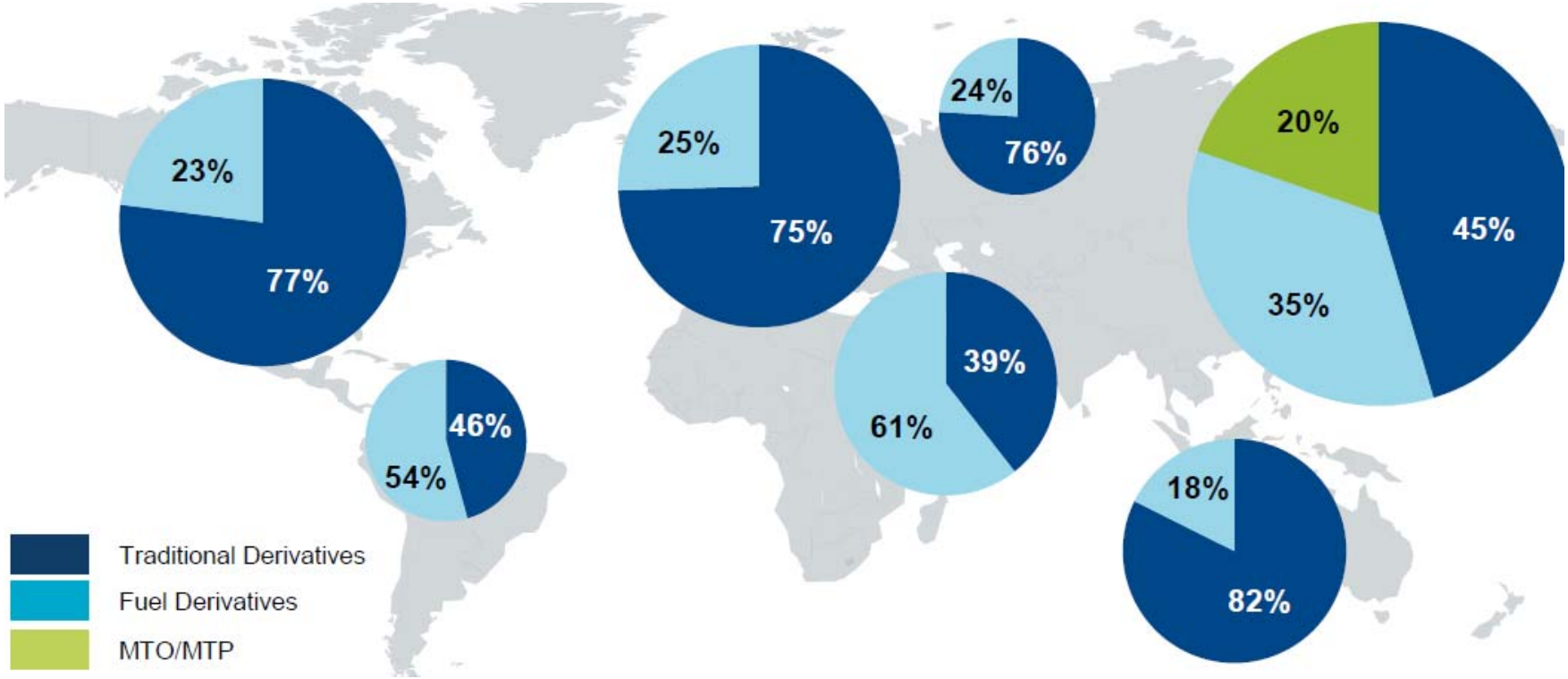
....the future?

03 Demand

Combustion engines remain dominant

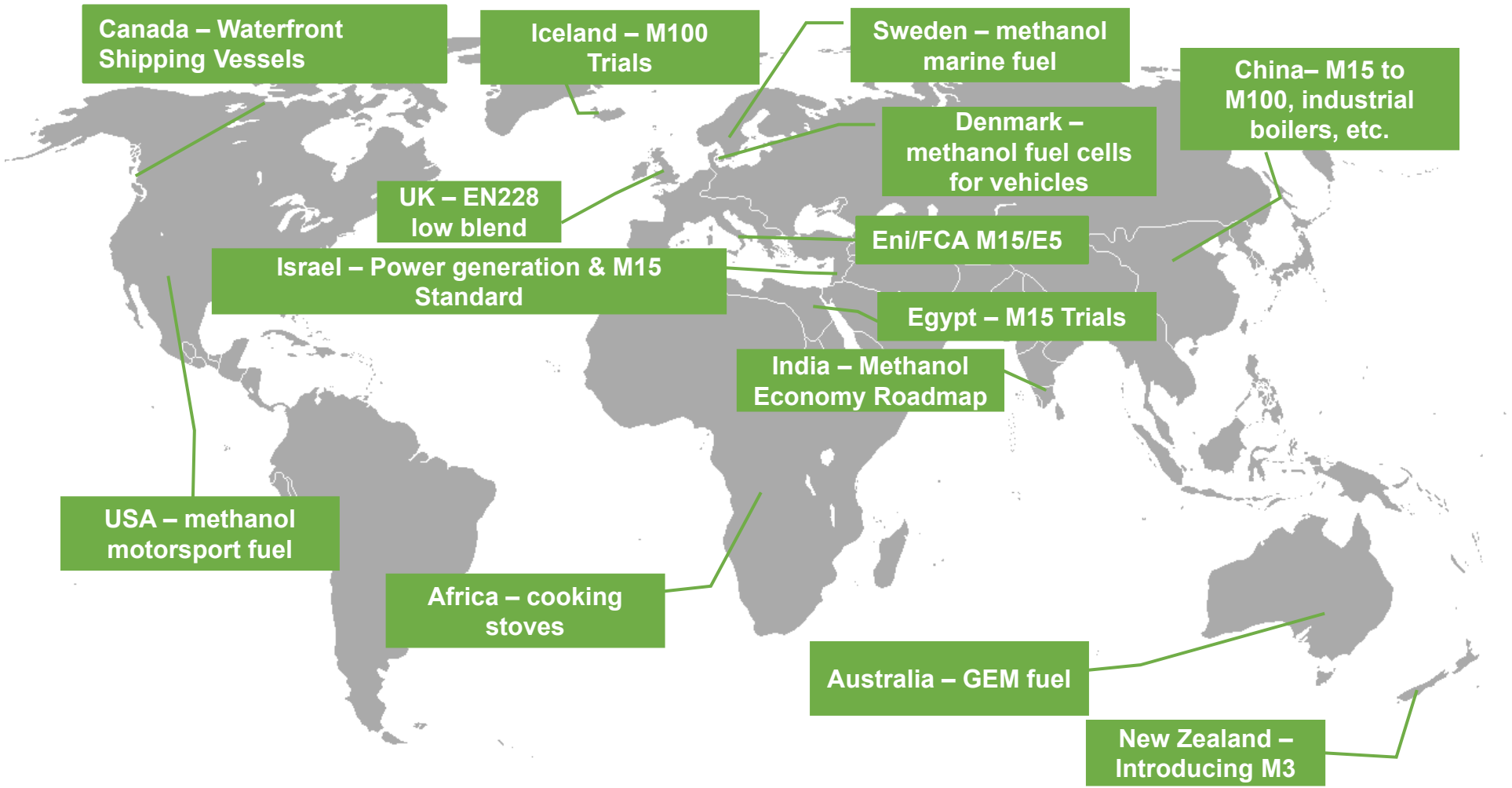


Oil displacement drives growth

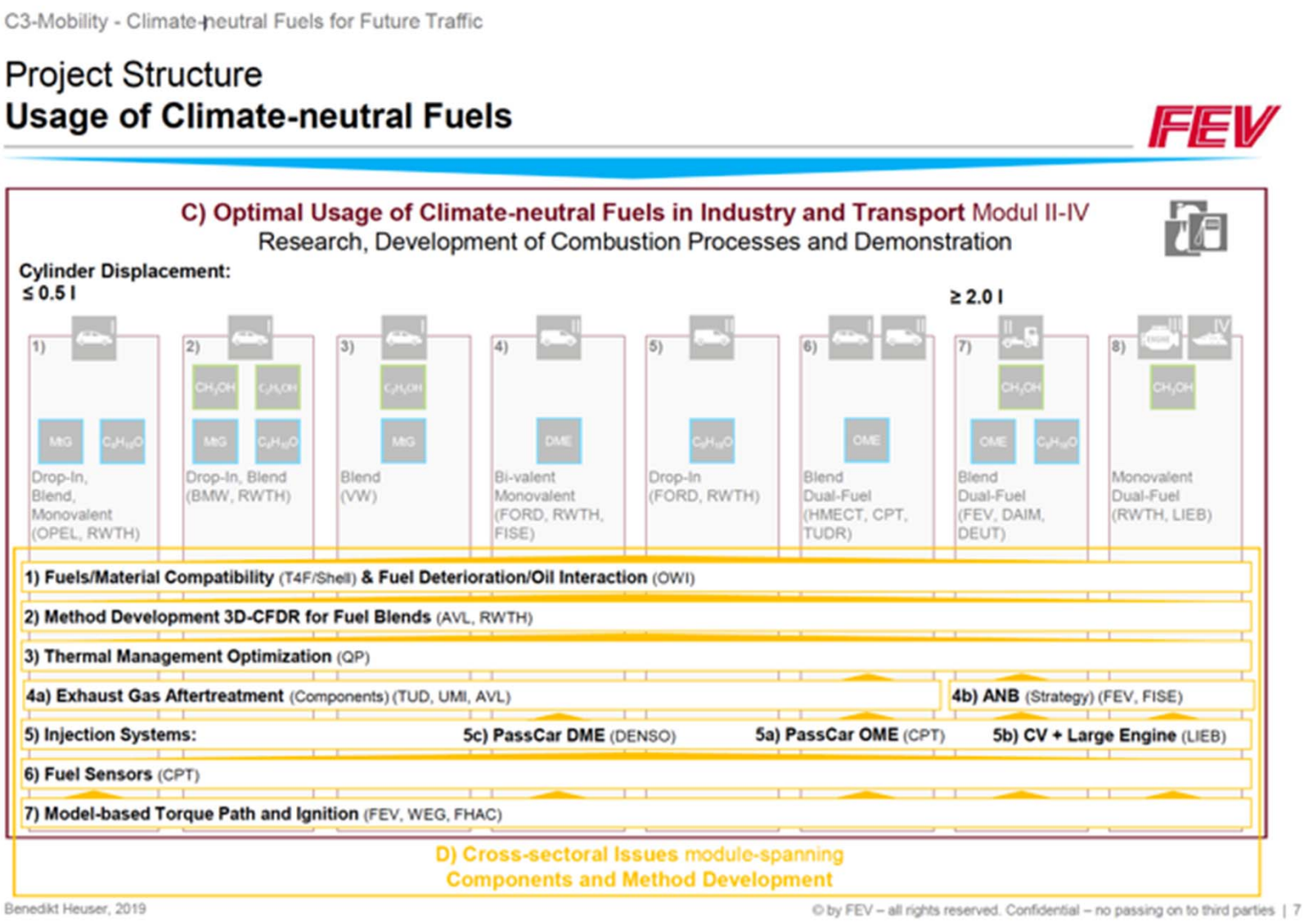


Source: IHS

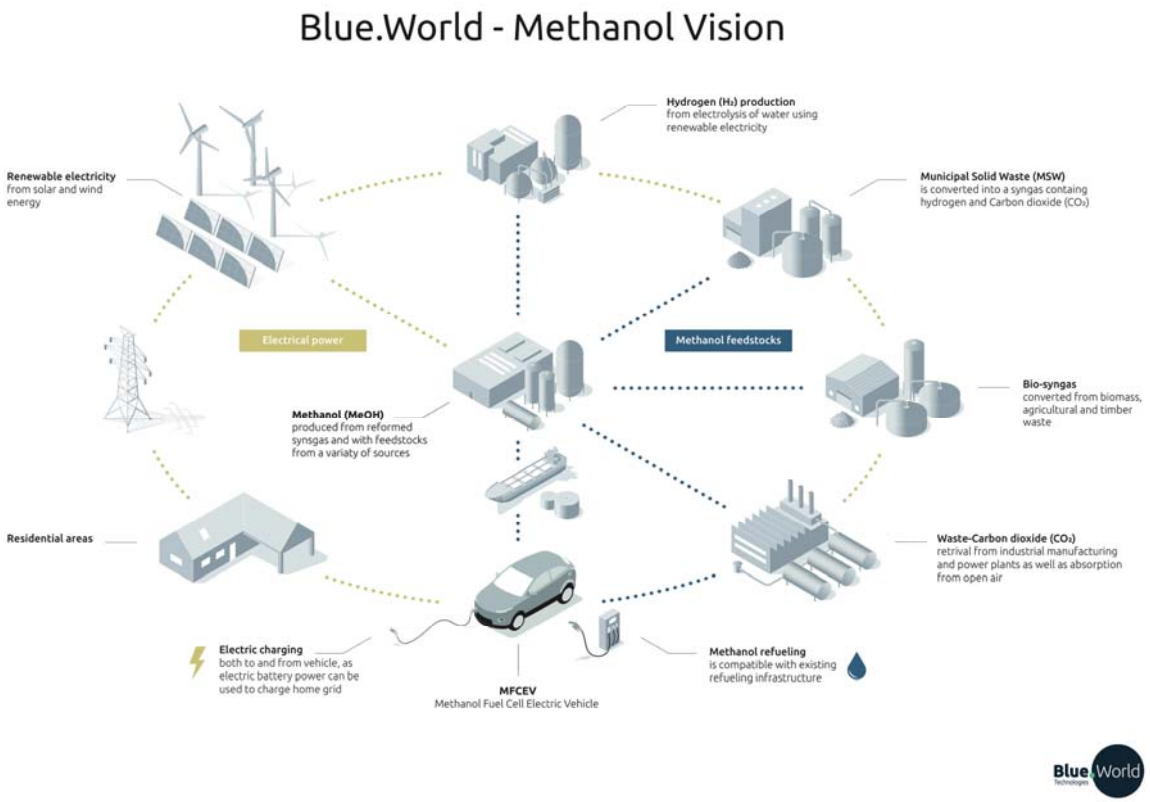
Methanol fuel use increasing globally



German OEMs investigate methanol fuels



Methanol fuel cell range extender







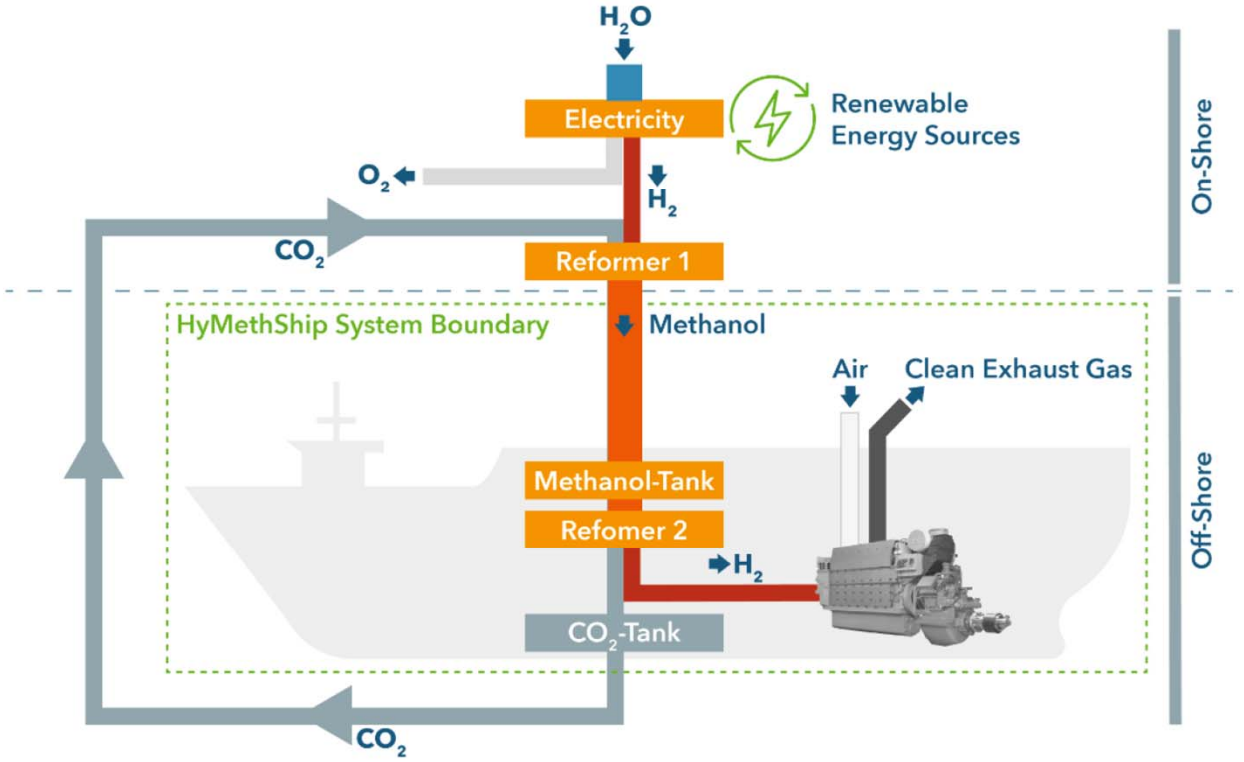
- 1.000 kilometer electric range
- 3 minutes refuelling
- Existing infrastructure



Closing the carbon cycle in marine

The Concept

HyMethShip



04 Policy

Policy leaves room for interpretation

E-fuels are categorized in Renewable Energy Directive 2 (RED2) as ‘Renewable Fuels of Non-biological Origin’

Specific details in the legislation leave room for interpretation at Member State level:



Either, share of renewability determined by national grid average from 2 years before



Or, 100% renewable provided a direct connection exists, and power is...

- not taken from the grid
- òr, when taken from the grid proof of sustainability is provided
- ànd, electricity is additional



E-fuels no longer recognised as Advanced Fuel

05 To conclude

The future is bright

E-Methanol is an opportunity to provide electricity in liquid form ('liquid electricity'), which makes it an interesting way to utilize carbon ànd store electricity because it:

- Uses mature technologies
- Enables energy efficient production, especially when integrated
- Can be used in existing engines and infrastructure
- Is suitable for road vehicles and ships, and for power as well as heat
- Reduces emissions
- Can be made economically viable

However, political bottleneck will have to be addressed to ensure a level playing field exists between all low carbon options (technology neutral)

METHANOL INSTITUTE

SINGAPORE (HQ)

10 Anson Road
#32-10 International Plaza
Singapore 079903
+ 65 6325 6300

WASHINGTON D.C.

225 Reinekers Lane
Suite 205
Alexandria, VA 22314
+1 (703) 248-3636

BRUSSELS

Square de Meeûs 38-40
B-1000 Brussels
Belgium
+32 241 6151

BEIJING

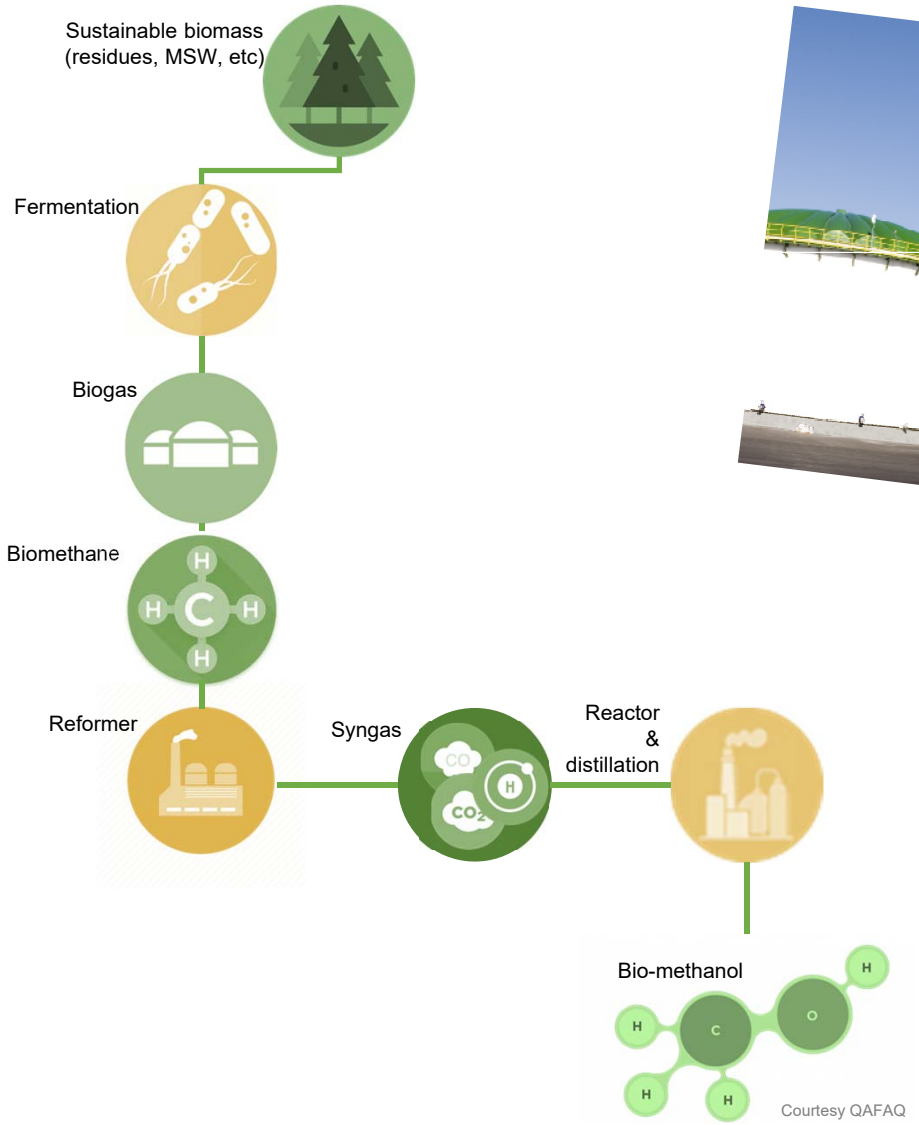
#511, Pacific Sci-tech
Development Center
Peking University
No. 52 Hai Dian Rd.
Beijing 100871, China
+86 10 6275 5984






Back up

Modern approach to biorefining

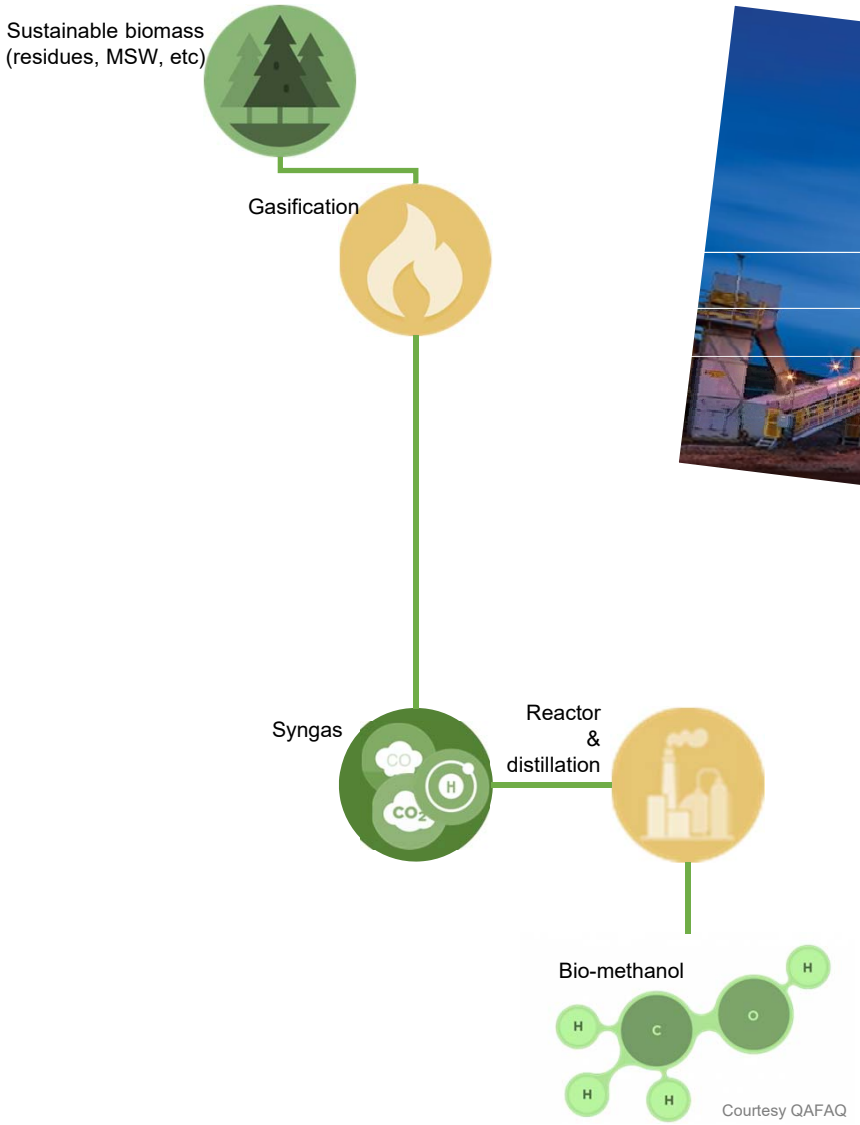




BioMCN, The Netherlands

BioMCN

Or gasification to syngas





Enerkem, Canada

Enerkem

And from pulp mill processes

Sustainable biomass
(residues, MSW, etc)

Kraft
process

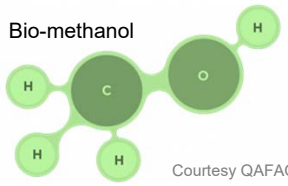


Södra, Sweden

SÖDRA

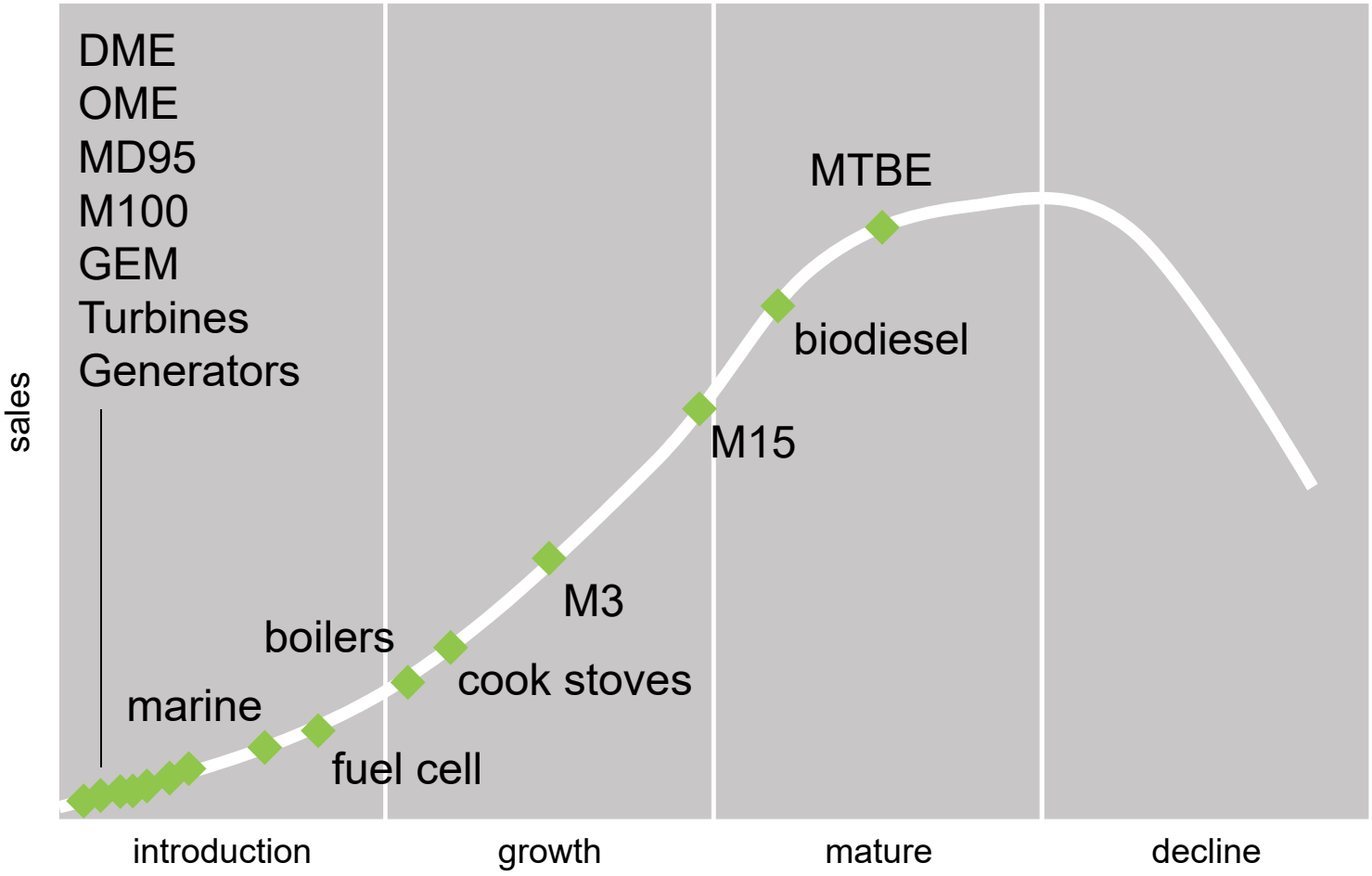
Reactor
&
distillation

Bio-methanol



Courtesy QAFAQ

Many energy applications still early in life cycle



Methanol synthesis

Several methanol synthesis catalysts are commercially available, with improved activity and selectivity. The catalysts are utilized for methanol synthesis from carbon monoxide, carbon dioxide and hydrogen.

$$CO + 2H_2 \leftrightarrow CH_3OH \qquad \Delta H_R = -91 \text{ kJ/mol}$$

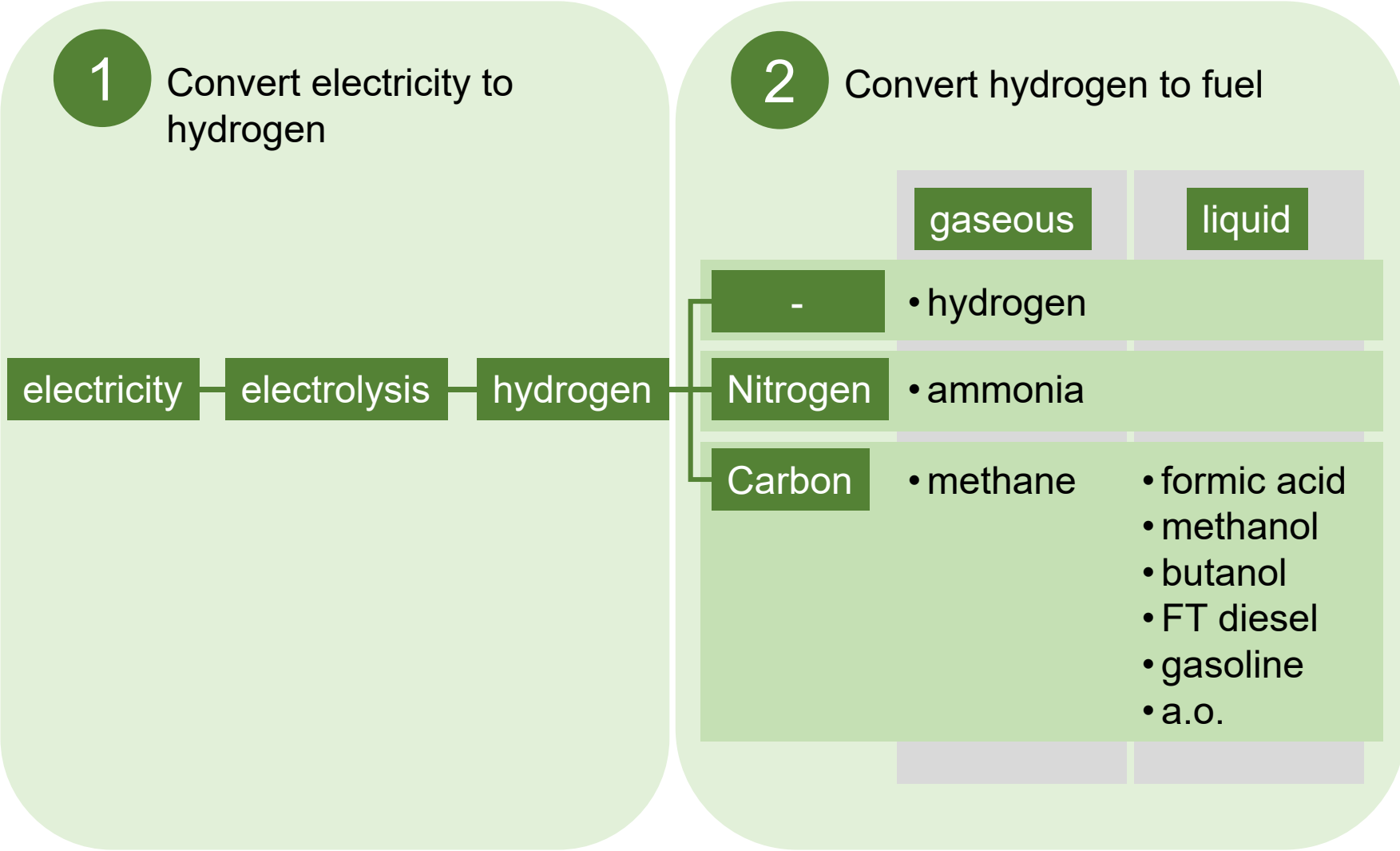
$$CO_2 + 3H_2 \leftrightarrow CH_3OH + H_2O \qquad \Delta H_R = -49 \text{ kJ/mol}$$

Both methanol forming reactions are interconnected with the water gas shift reaction:

$$CO + H_2O \leftrightarrow CO_2 + H_2 \qquad \Delta H_R = -42 \text{ kJ/mol}$$

The above equilibrium reactions are exothermic, so low reaction temperatures and high reaction pressures favor methanol yield.

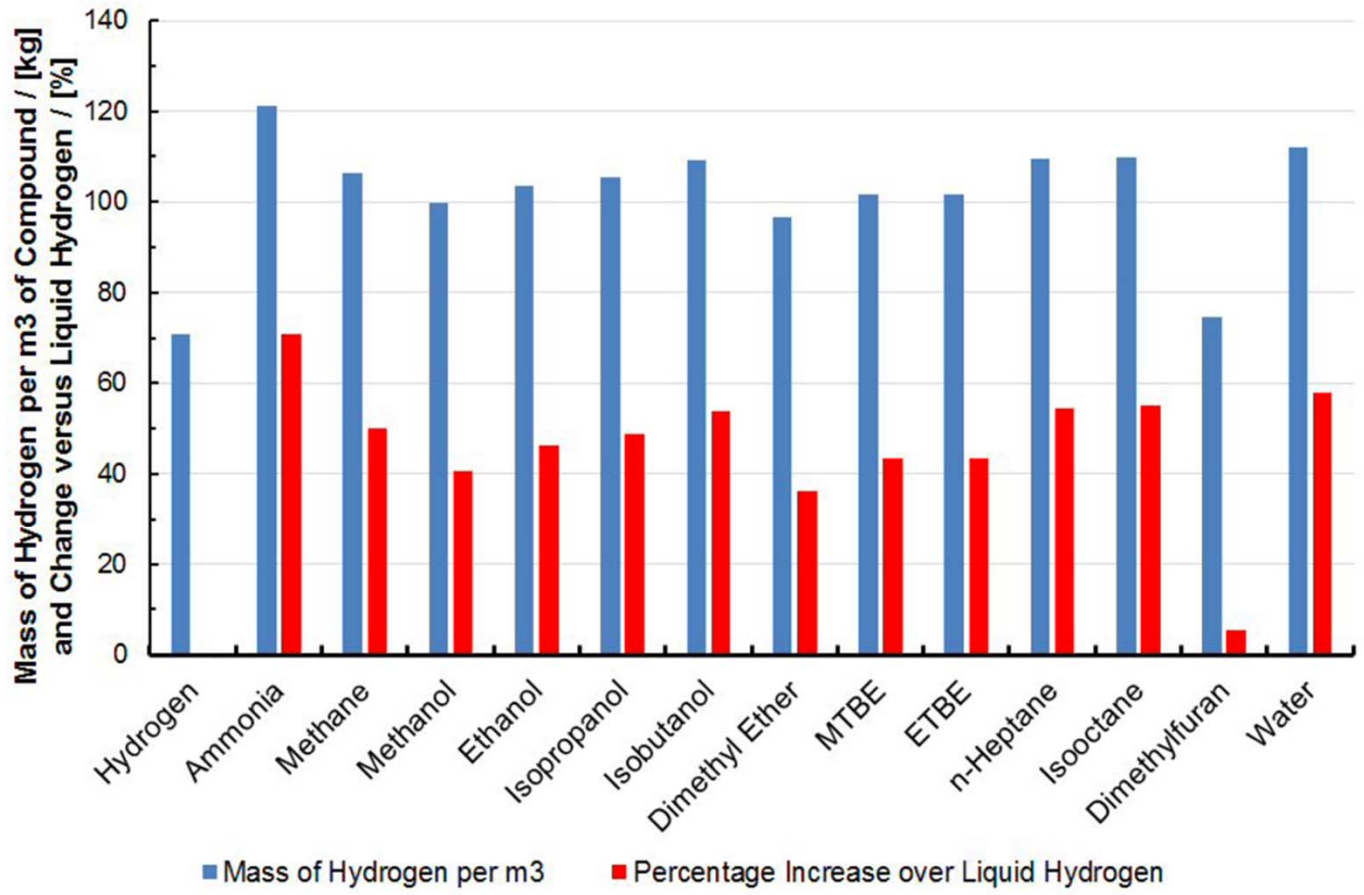
PtX and CCU are similar but not the same



Methanol is a great energy carrier

H_2: very bad at storing H_2

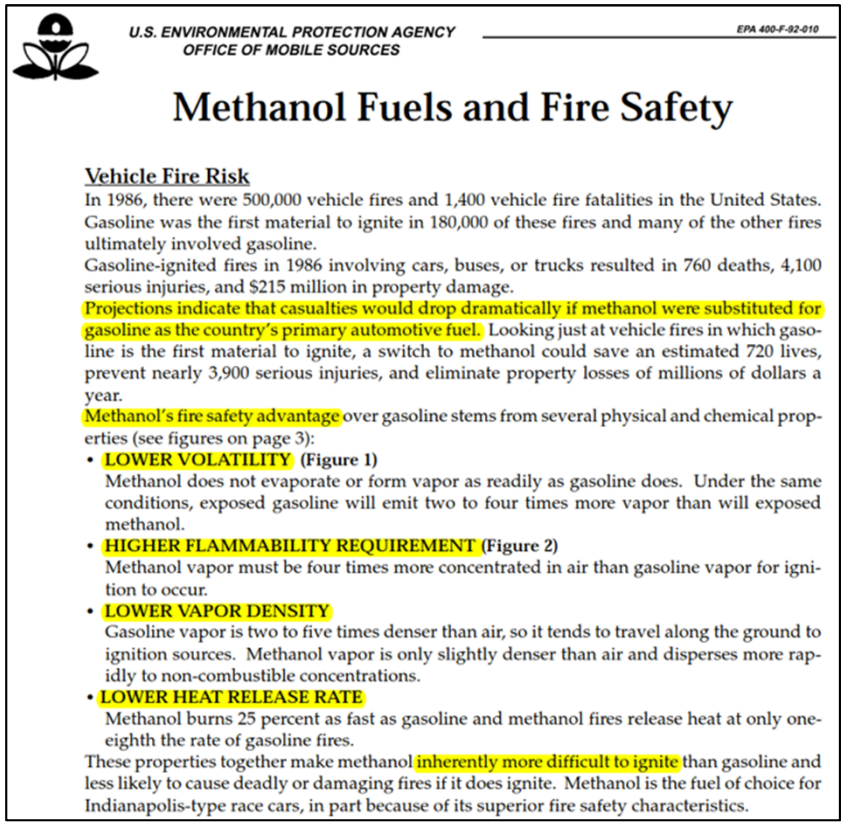
LeanShips
Low Energy And
Near to zero emissions Ships



Comparing apples to apples

	METHANOL	DIESEL	GASOLINE
Hazard pictograms (CPL)			
Signal word: (CPL)	Danger	Danger	Danger
Hazard statements (CPL)	H225 Highly flammable liquid and vapour. H301 Toxic if swallowed. H311 Toxic in contact with skin. H331 Toxic if inhaled. H370 Causes damage to organs.	H226: Flammable liquid and vapour. H304: May be fatal if swallowed and enters airways. H315: Causes skin irritation. H332: Harmful if inhaled. H351: Suspected of causing cancer. H373: May cause damage to organs through prolonged or repeated exposure. H411: Toxic to aquatic life with long lasting effects	H224: Extremely flammable liquid and vapour. H304: May be fatal if swallowed and enters airways H315: Causes skin irritation H340: May cause genetic defects H350: May cause cancer H361: Suspected of damaging fertility or the unborn child H336: May cause drowsiness or dizziness H411: Toxic to aquatic life with long lasting effects
Precautionary statements (CLP)	P210 - Keep away from heat. - No smoking P280 - Wear protective gloves, protective clothing, eye protection, face protection P304+P340 - IF INHALED: remove victim to fresh air and keep at rest in a position comfortable for breathing P303+P361+P353 - IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower P301+P310 - IF SWALLOWED: Immediately call a POISON CENTRE or doctor P403+P235 - Store in a well-ventilated place. Keep cool	P201: Obtain special instructions before use P210: Keep away from heat/sparks/open flames/hot surfaces – No smoking P240: Ground/bond container and receiving equipment P241: Use explosion-proof electrical/ventilation/ lightning equipment P242: Use only non-sparing tools P243: Take precautionary measures against static discharge P260: Do not breathe dust/fume/gas/vapours/spray P264: Wash hands thoroughly after handling P270: Do not eat, drink or smoke when using this product P273: Avoid release to the environment P280: Wear protective gloves/clothing/eye protection P301+P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician P302+P352: IF ON SKIN: Wash with plenty of soap and water P303+P361+P353: IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower P304+P340: IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing P308+P313: IF exposed or concerned: Get medical advice/attention P312: Call a POISON CENTER or doctor/physician if you feel unwell P331: Do NOT induce vomiting P352+P313: If skin irritation occurs: Get medical advice/attention P370+P378: In case of fire: Use water spray or foam for extinction P391: Collect spillage P403+P233: Store in a well-ventilated place. Keep container tightly closed P403+P235: Store in a well-ventilated place. Keep cool P405: Store locked up P501: Dispose of contents/container in accordance with local/regional/national/international regulation	P201: Obtain special instructions before use P202: Do not handle until all safety precautions have been read and understood P210: Keep away from heat/sparks/open flames/hot surfaces - No smoking P233: Keep container tightly closed P240: Ground/bond container and receiving equipment P241: Use explosion-proof electrical/ventilation/ lightning equipment P242: Use only non-sparing tools P243: Take precautionary measures against static discharge P261: Do not breath fume/gas/mist/vapours/spray P264: Wash hands thoroughly after handling P271: Use only outdoors or in a well-ventilated area P273: Avoid release to the environment P280: Wear protective gloves/clothing/eye protection P301+P310: IF SWALLOWED: Immediately call a POISON CENTER or doctor/physician P302+P352: IF ON SKIN: Wash with plenty of soap and water P303+P361+P353: IF ON SKIN (or hair): Remove/Take off immediately all contaminated clothing. Rinse skin with water/shower P304+P340: IF INHALED: Remove victim to fresh air and keep at rest in a position comfortable for breathing P308+P313: IF exposed or concerned: Get medical advice/attention P312: Call a POISON CENTER or doctor/physician if you feel unwell P331: Do NOT induce vomiting P352+P313: If skin irritation occurs: Get medical advice/attention P370+P378: In case of fire: Use water spray or foam for extinction P391: Collect spillage P403+P235: Store in a well-ventilated place. Keep cool P405: Store locked up P501: Dispose of contents/container in accordance with local/regional/national/international regulation

Less dangerous than gasoline



U.S. ENVIRONMENTAL PROTECTION AGENCY
OFFICE OF MOBILE SOURCES

EPA 400-F-92-010

Methanol Fuels and Fire Safety

Vehicle Fire Risk

In 1986, there were 500,000 vehicle fires and 1,400 vehicle fire fatalities in the United States. Gasoline was the first material to ignite in 180,000 of these fires and many of the other fires ultimately involved gasoline.

Gasoline-ignited fires in 1986 involving cars, buses, or trucks resulted in 760 deaths, 4,100 serious injuries, and $215 million in property damage.

Projections indicate that casualties would drop dramatically if methanol were substituted for gasoline as the country's primary automotive fuel. Looking just at vehicle fires in which gasoline is the first material to ignite, a switch to methanol could save an estimated 720 lives, prevent nearly 3,900 serious injuries, and eliminate property losses of millions of dollars a year.

Methanol's fire safety advantage over gasoline stems from several physical and chemical properties (see figures on page 3):

- **LOWER VOLATILITY (Figure 1)**
  Methanol does not evaporate or form vapor as readily as gasoline does. Under the same conditions, exposed gasoline will emit two to four times more vapor than will exposed methanol.
- **HIGHER FLAMMABILITY REQUIREMENT (Figure 2)**
  Methanol vapor must be four times more concentrated in air than gasoline vapor for ignition to occur.
- **LOWER VAPOR DENSITY**
  Gasoline vapor is two to five times denser than air, so it tends to travel along the ground to ignition sources. Methanol vapor is only slightly denser than air and disperses more rapidly to non-combustible concentrations.
- **LOWER HEAT RELEASE RATE**
  Methanol burns 25 percent as fast as gasoline and methanol fires release heat at only one-eighth the rate of gasoline fires.

These properties together make methanol inherently more difficult to ignite than gasoline and less likely to cause deadly or damaging fires if it does ignite. Methanol is the fuel of choice for Indianapolis-type race cars, in part because of its superior fire safety characteristics.

TABLE 6-1
HAZARD SUMMARY[a]

	M100	Gasoline
Flammability		
Ease of Occurrence		
Open & Restricted Areas	4	9
Enclosed Spaces	8 (2-4) [b]	2
Relative Hazard if Fire		
Fire Severity	3	10
Ease of Extinguishing	7	10
Flame Visibility	8	1
Toxicity		
Inhalation-Low Conc.		
Toxicity	3	10
Ease of Occurrence	10	10
Inhalation - High Conc.		
Toxicity	10	10
Ease of Occurrence	3	4
Skin Contact.		
Toxicity	9	8
Ease of Occurrence	3	3
Ingestion		
Toxicity	10	10
Ease of Occurrence	8(2) [c]	3

Table adapted from Machiele, 1998; [a] 1-No concern. 2 to 3 = Low Level concern. 4 to 6 = moderate concern. 7 to 8 = high-level concern. 9 to 10 = extreme hazard. [b] Numbers in parenthesis reflect hazard reductions resulting from design changes. [C] Number in parenthesis incorporates the lowered likelihood of ingestion due to the presence of additives.

Source: Malcolm Pirnie, Inc. , Technical Memorandum

Methanol has lower fire risk

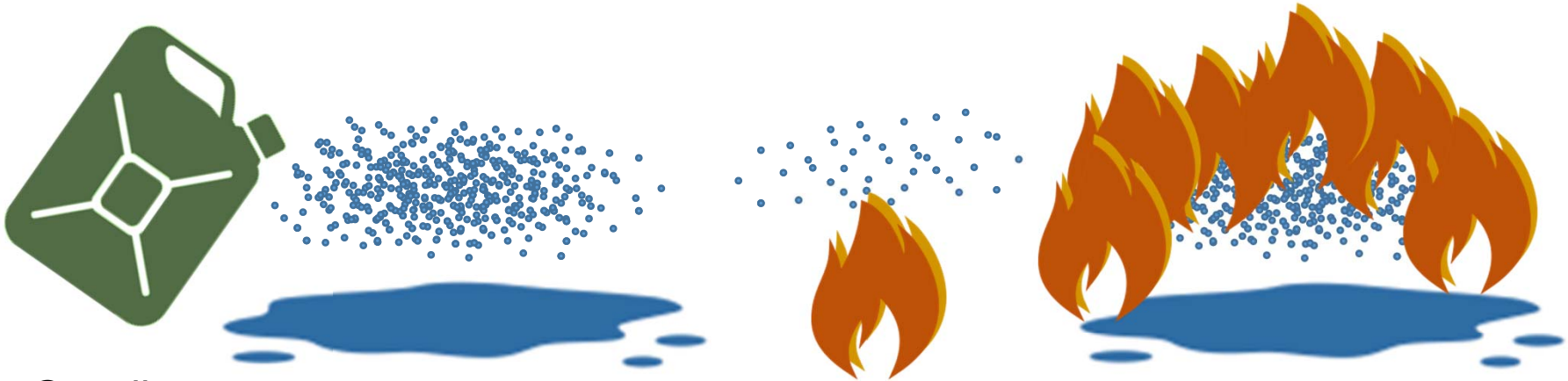


Methanol

evaporates slowly

needs lots of vapour to burn

confined fire zone;
fires less likely



Gasoline

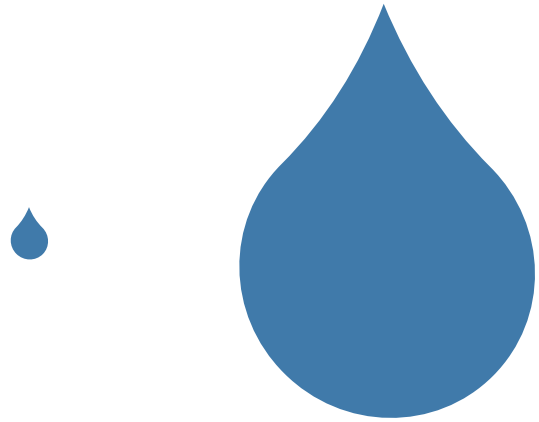
evaporates fast

needs little vapour to burn

broad fire zone;
fires more likely

Putting things in perspective

LC50 - Lethal dosis fish



Gasoline [1]
8,2 mg/l

Diesel [2]
65 mg/l

Methanol
15.400 mg/l

Sources:
[1] Petrobras/Statoil ASA, Safety Data Sheet, ECHA registration dossier Gasoline
[2] ECHA, European Chemical Agency, registration dossier Diesel
[3] ECHA, European Chemical Agency, registration dossier Methanol

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