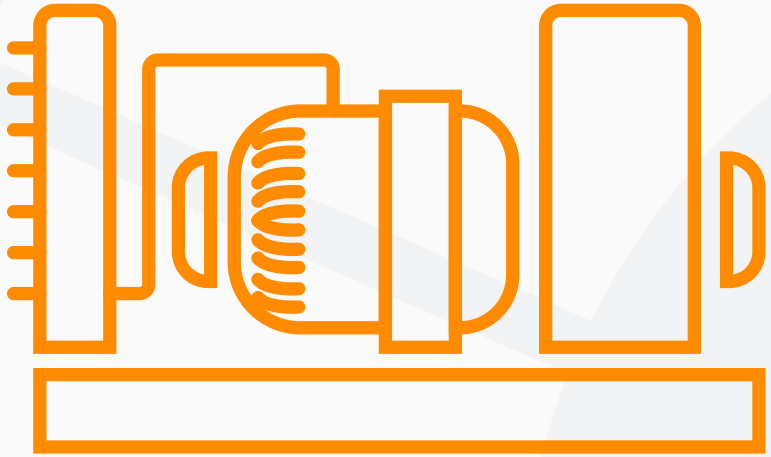


Alternative Fuel Gas Turbines

NZTTP Programme

Topsides UK
November 2023

apollo

Net Zero Technology Centre

Technology Driving Transition

ETF Alternative Fuels Gas Turbine – Key Objectives

Clean, remote power generation - Accelerating development of gas turbines (or reciprocating engines) capable of running on clean fuels.

Develop a zero-carbon fuel **retrofit** solution for aero-derivative gas turbines.

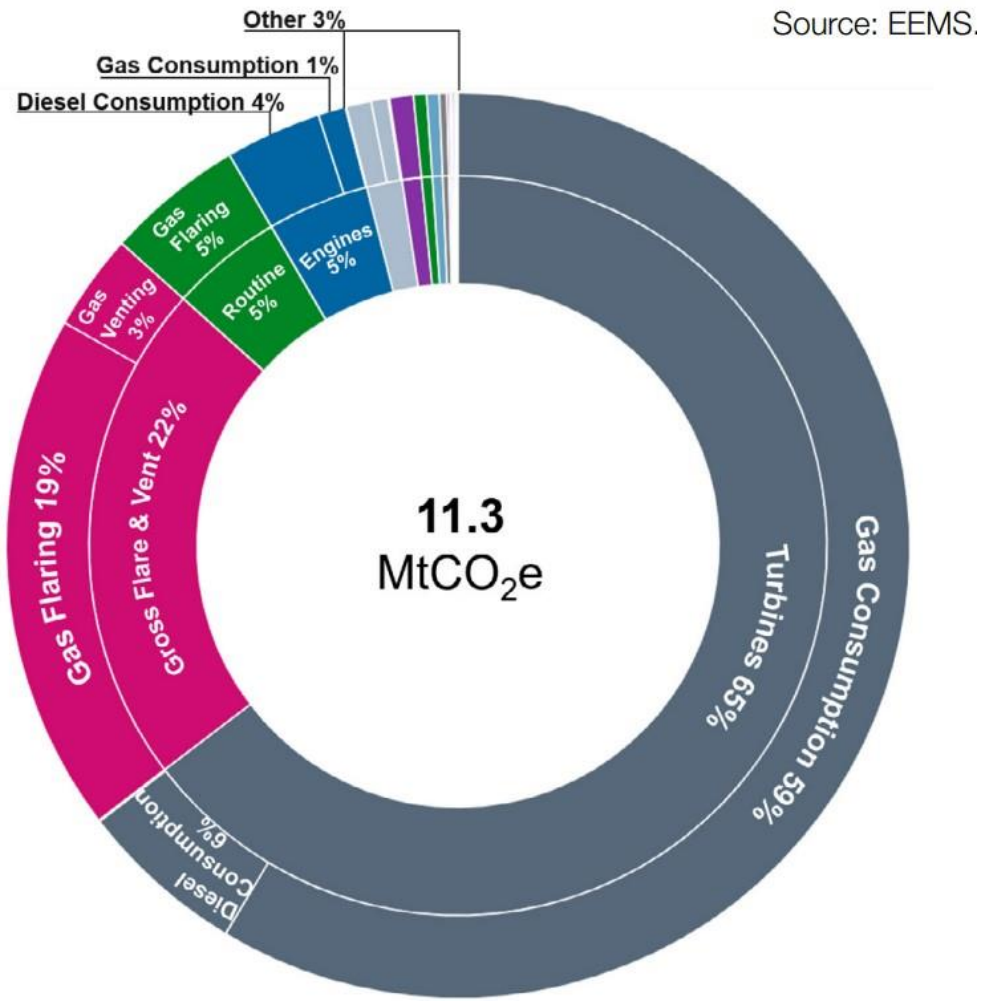
Anchor Scotland's existing gas turbine supply chain in this new market – by performing the R&D and developing the technology and skills locally.

Stimulate growth in the local alternative fuel production market by creating new local **demand**.

Create and sustain Scottish jobs in the gas turbine repair and maintenance sector, through exporting the technology and skills to other sectors and countries.

Extend field life and delay decommissioning of UKCS assets by improving operating efficiency.

Why Alternative Fuels?

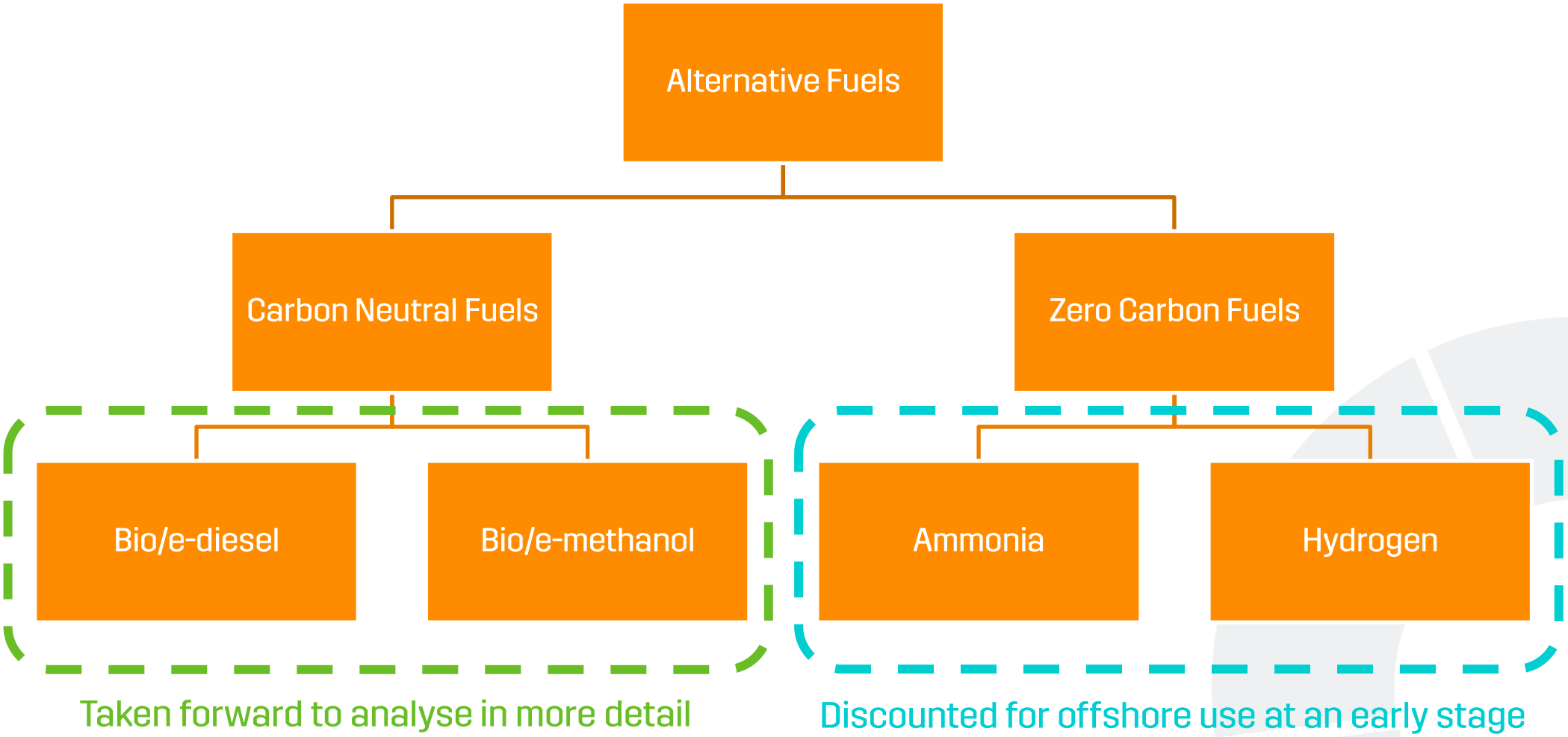


Source: EEMS.

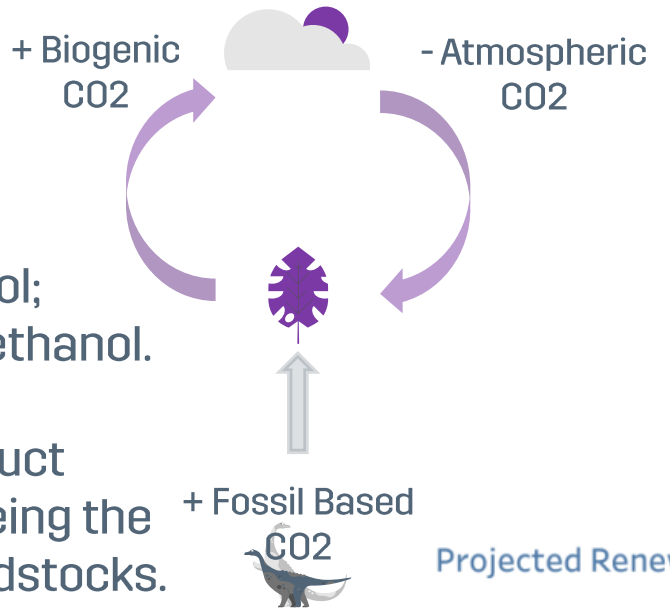
GHG Emission Reduction from 2018 Baseline	Year
10%	2025
25%	2027
50%	2030
100% (Net Zero)	2050

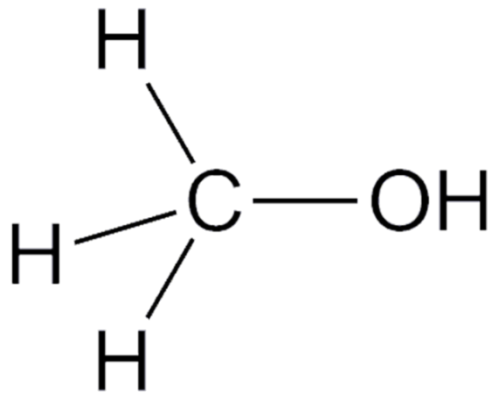
Alternative Fuels

Alternative Fuel Gas Turbines
NZTTP Programme

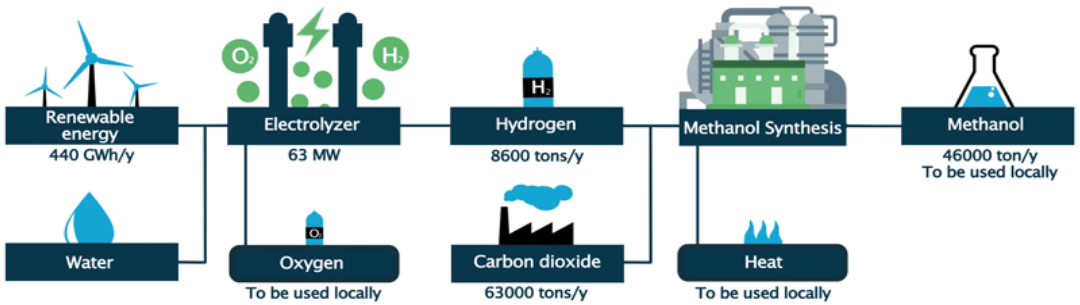


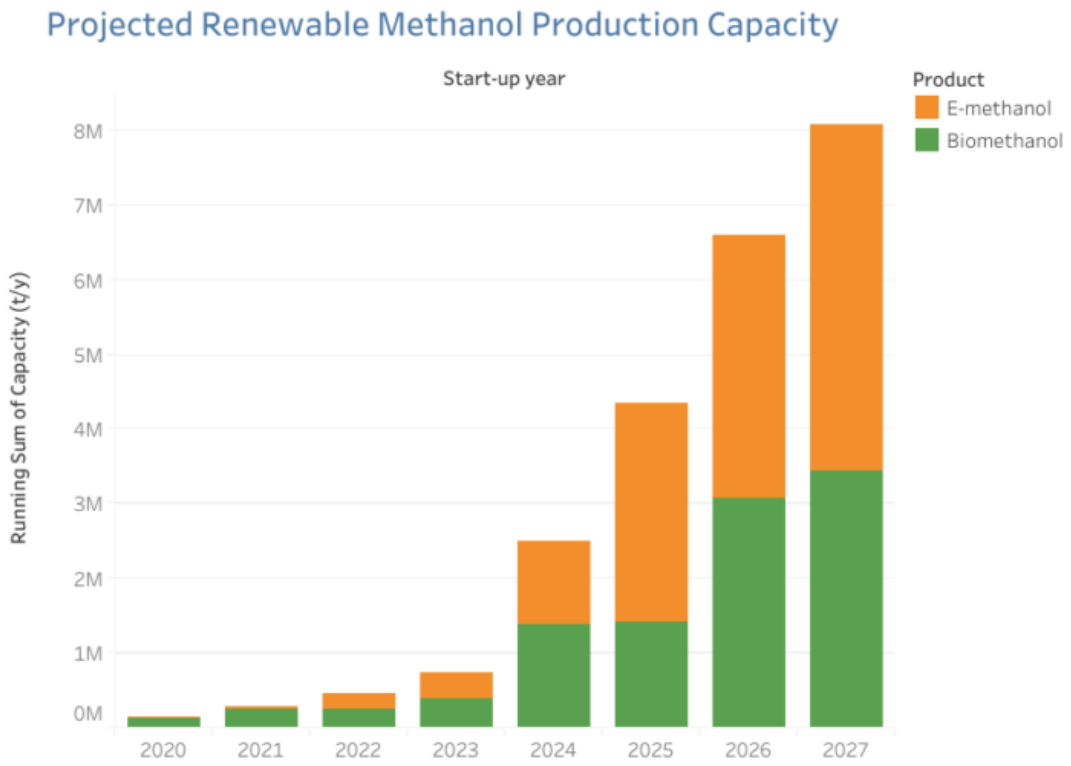
Green Methanol





- Simplest of the alcohols
- There are different types of methanol; including conventional, bio and e-methanol.
- All three are have identical end product properties, with the differentiator being the production processes and input feedstocks.
- To be considered green, all feedstocks and energy used to produce the medium must be of renewable sources, as defined by RED II.





Source : Methanol Institute Renewable Methanol Database of Current/Announced Projects

Ecotoxicological Values

LC50 96hour

Methanol
15,400 (mg/l)

Ammonia
0.75-3.4 (mg/l)

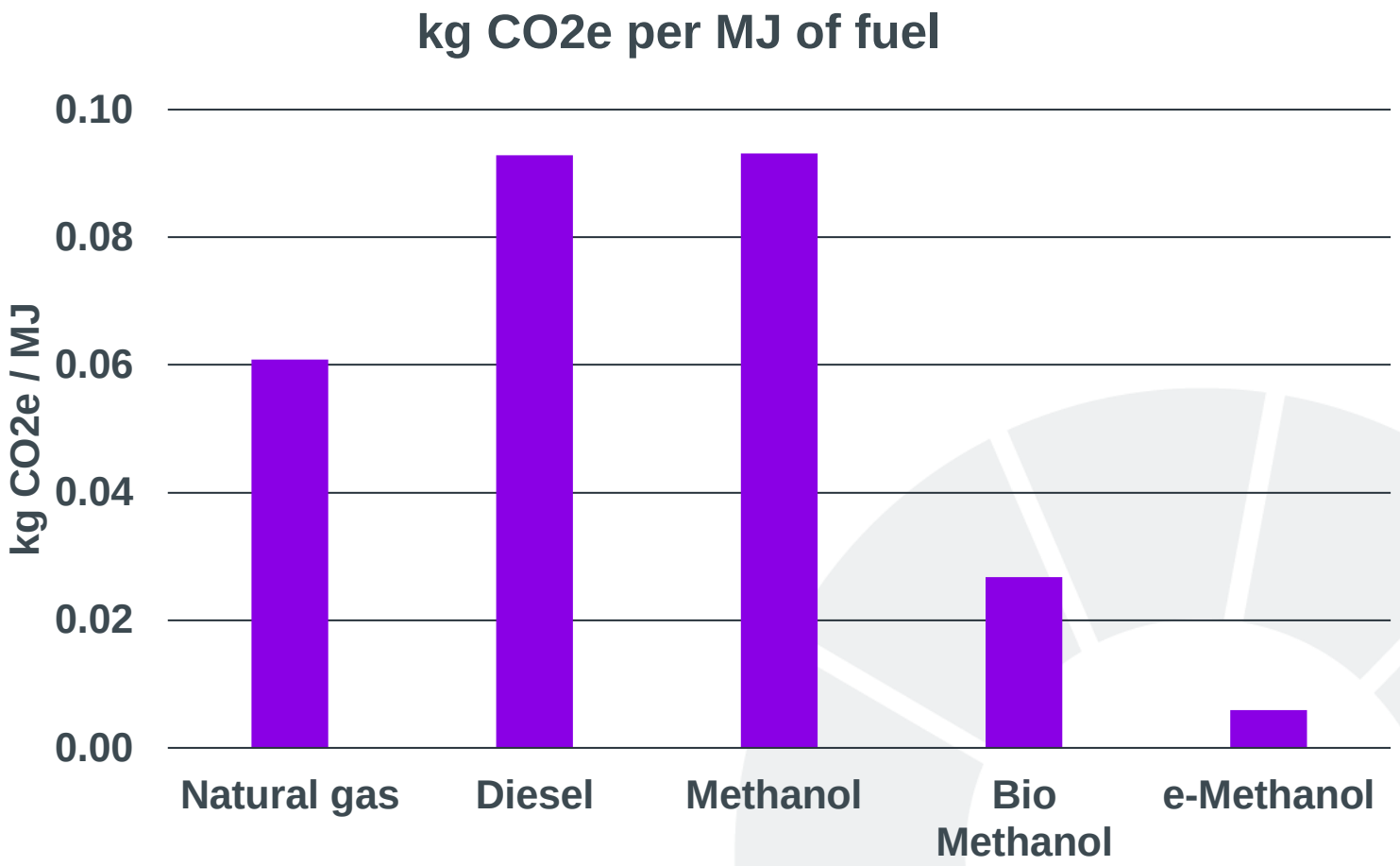
Gasoline
8.2 (mg/l)

Kerosene
2-5 (mg/l)

Diesel
21 (mg/l)

Green Methanol - Combustion

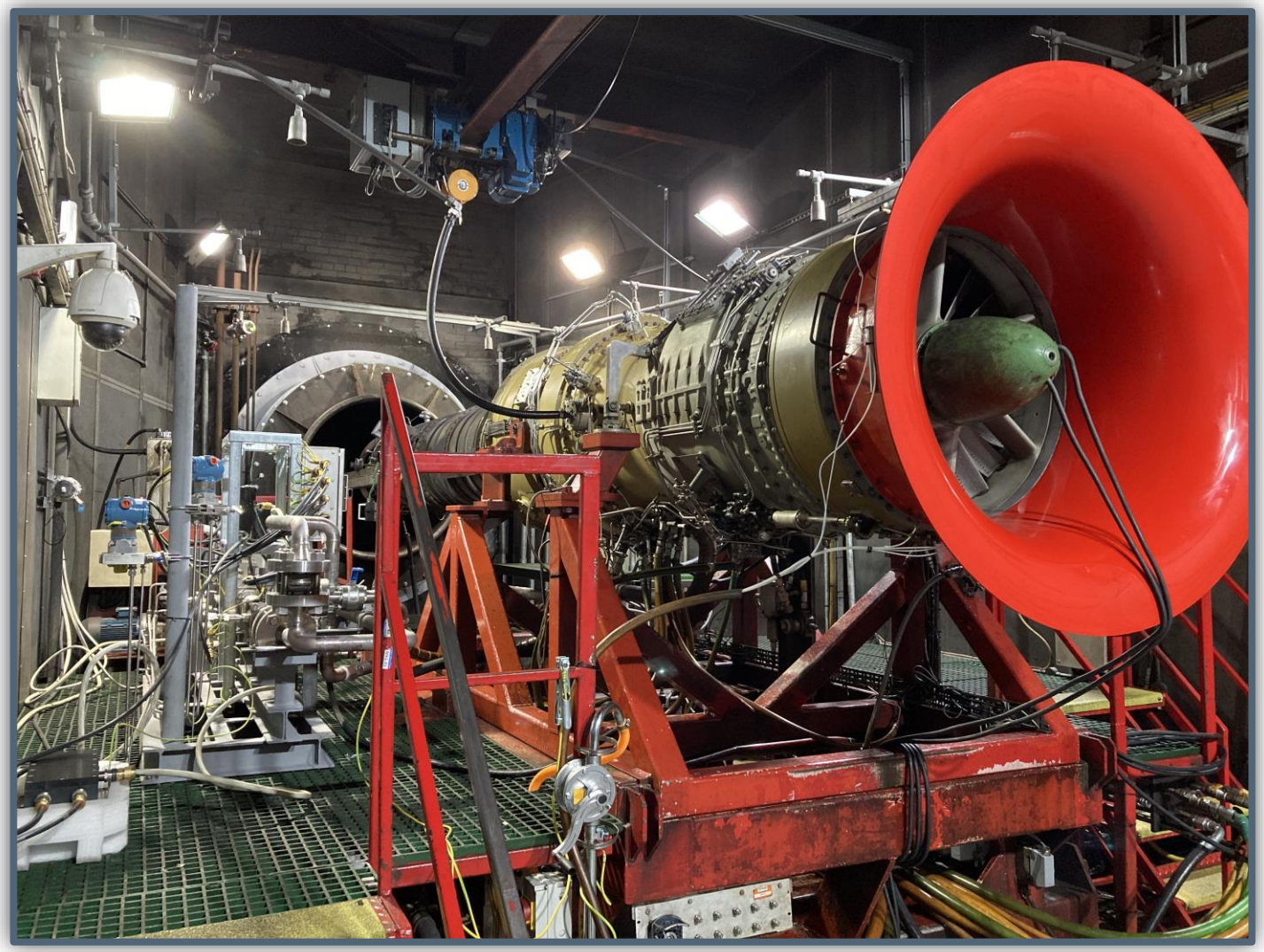
- Methanol can be synthetically manufactured using green hydrogen and captured CO2 (e-methanol) or created from Biomass (Bio-methanol)
- Proven up to 80% reduction in NOx from non-DLE gas turbines – improving air quality and reducing smog
- Methanol eliminates SO2, PM and smoke emissions
- Methanol burns cleaner and cooler than conventional liquid fuels, extending the field life of turbines



Bio-Methanol Demonstration Test

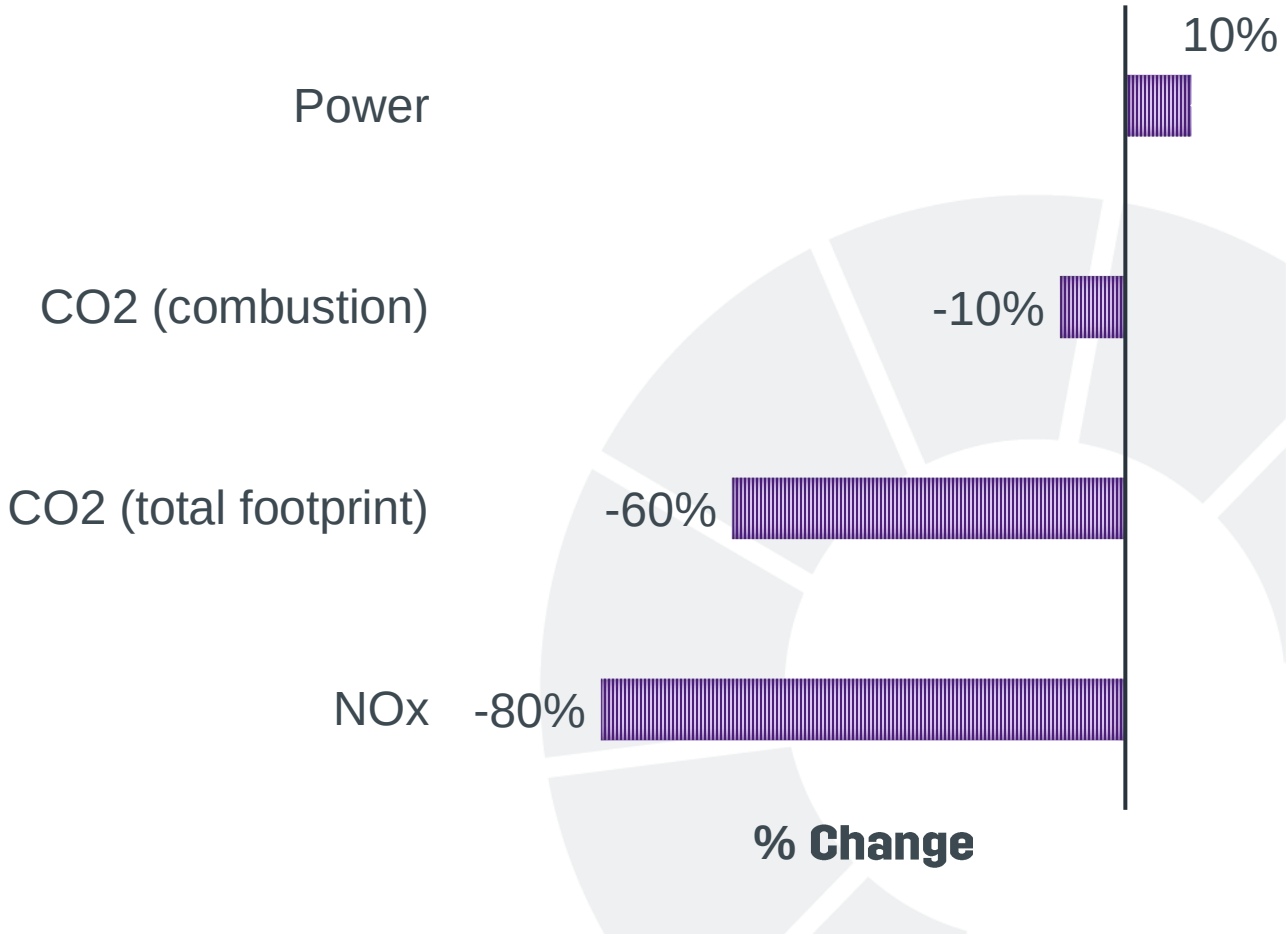
SIEMENS energy

Alternative Fuel Gas Turbines
NZTTP Programme



Bio-methanol test results

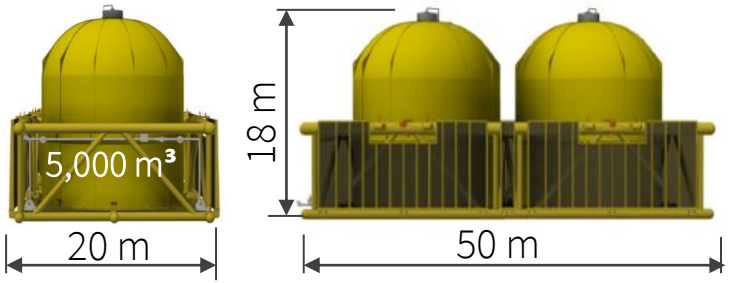
- 10% Power increase at same operating temperature ✓
- 80% NOx reduction ✓
- No impact on CO emissions ✓
- 10% CO2 reduction from direct combustion – total 60% reduction in total CO2 footprint of fuel ✓
- Operability ✓
- Start up on methanol fuel ✓
- Shutdown on methanol fuel ✓
- Demonstration of safe system and gas turbine operation ✓

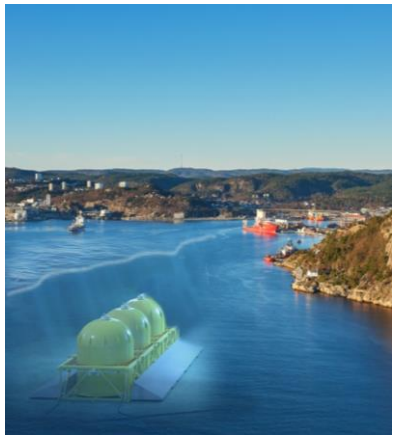


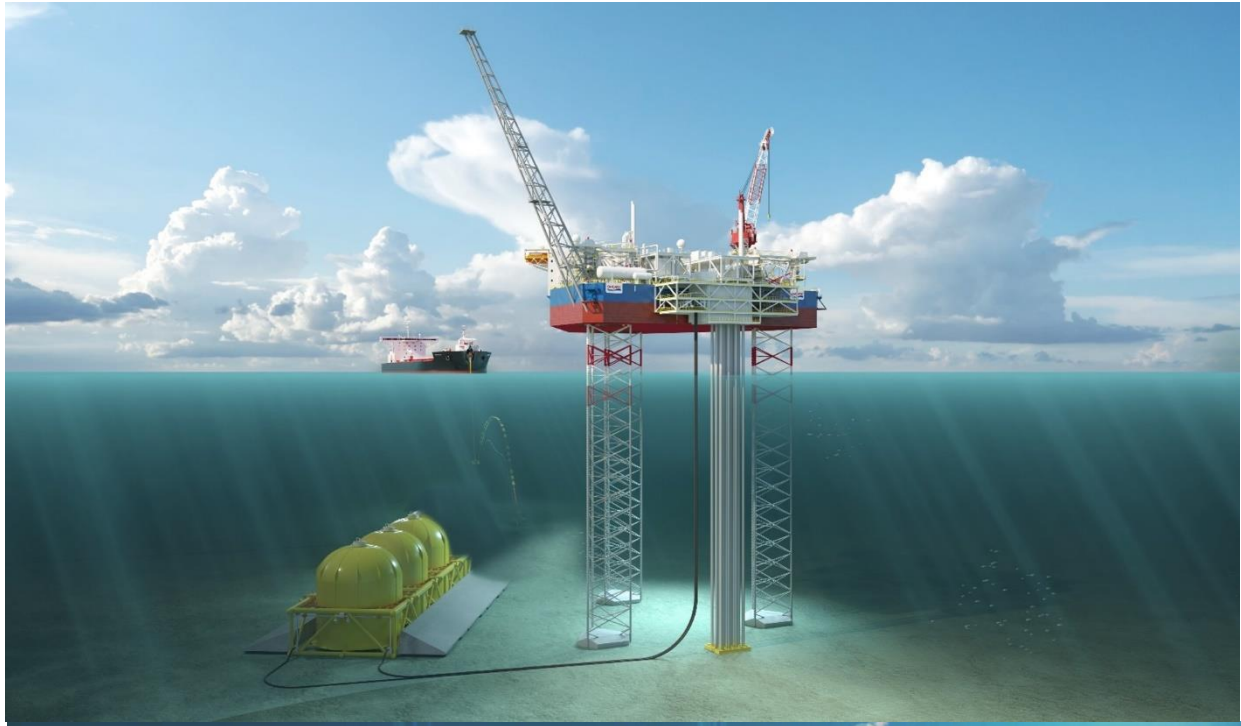
Subsea Energy Storage

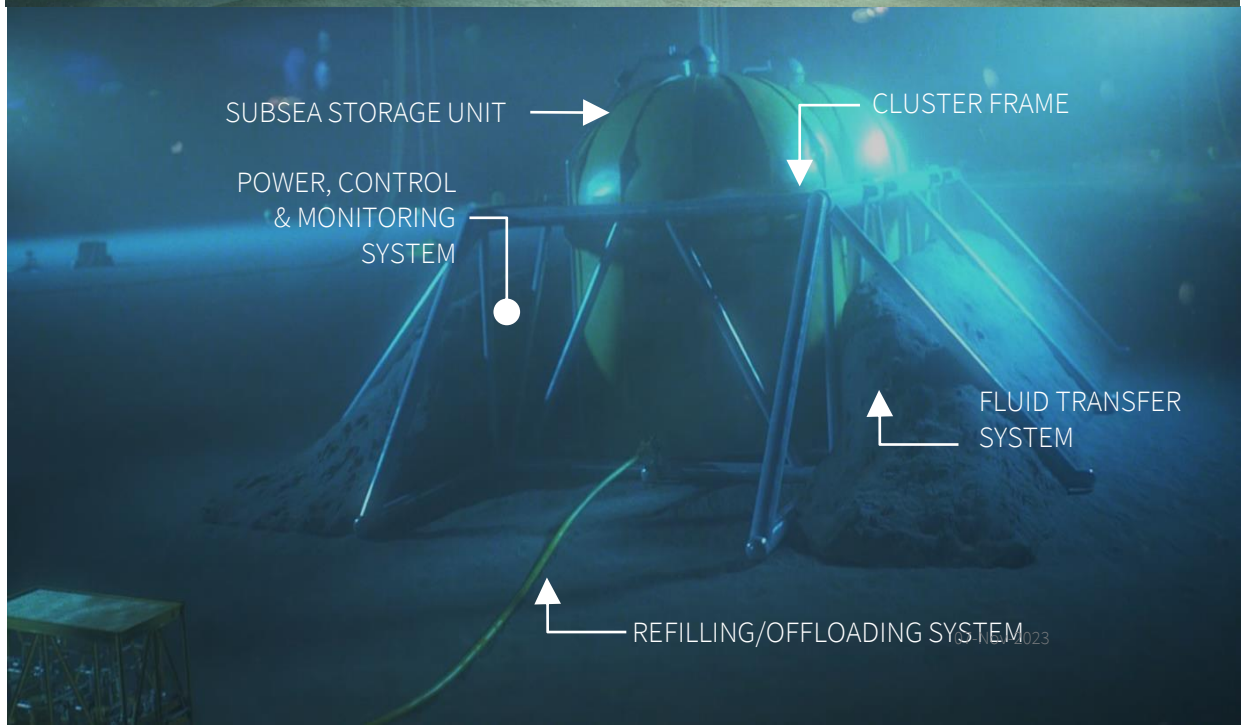
Ammonia/methanol

- Storage/bunkering at ambient pressure and temperature, by environmental conditions
- Flexible size and capacity
  - up to 10,000m³ with a cluster frame up to 50,000m³
  - Protective structure in fiberglass, GRP
- Continuous level monitoring and leakage detection









White papers

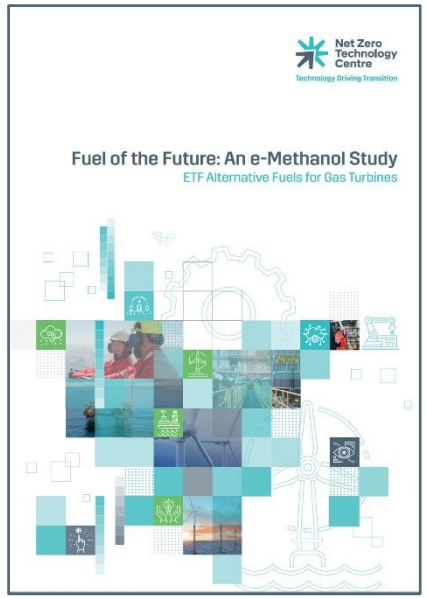
Alternative Fuel Gas Turbines
NZTTP Programme

E-methanol

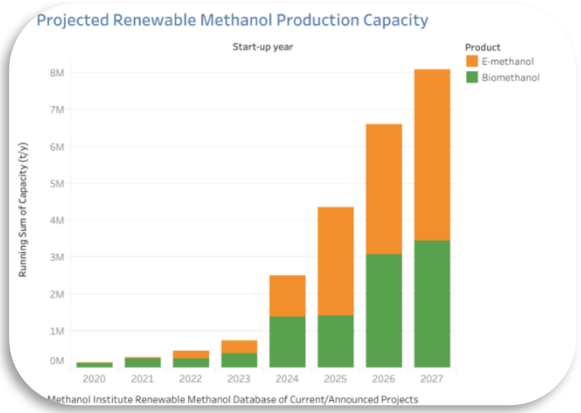
Net Zero Technology Centre
Technology Driving Transition

Landscaping study on e-MeOH.

Study Completed in February 2023. Available to download on NZTC website.



METHANOL INSTITUTE

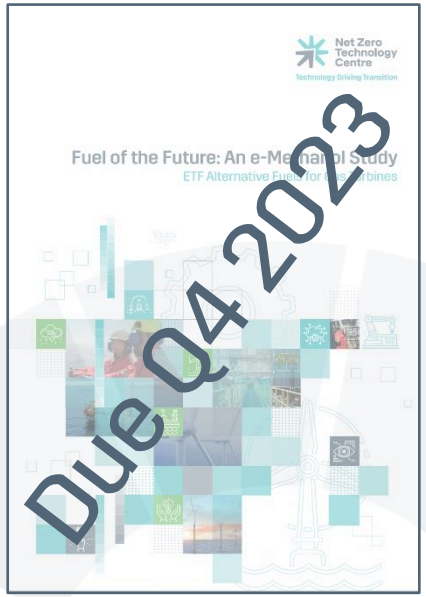


Alternative Diesel

apollo

Landscaping study on Diesel Alternatives, including FAME, HVO and e-diesel.

Study Due in Q4 2023. Will be publicly available.

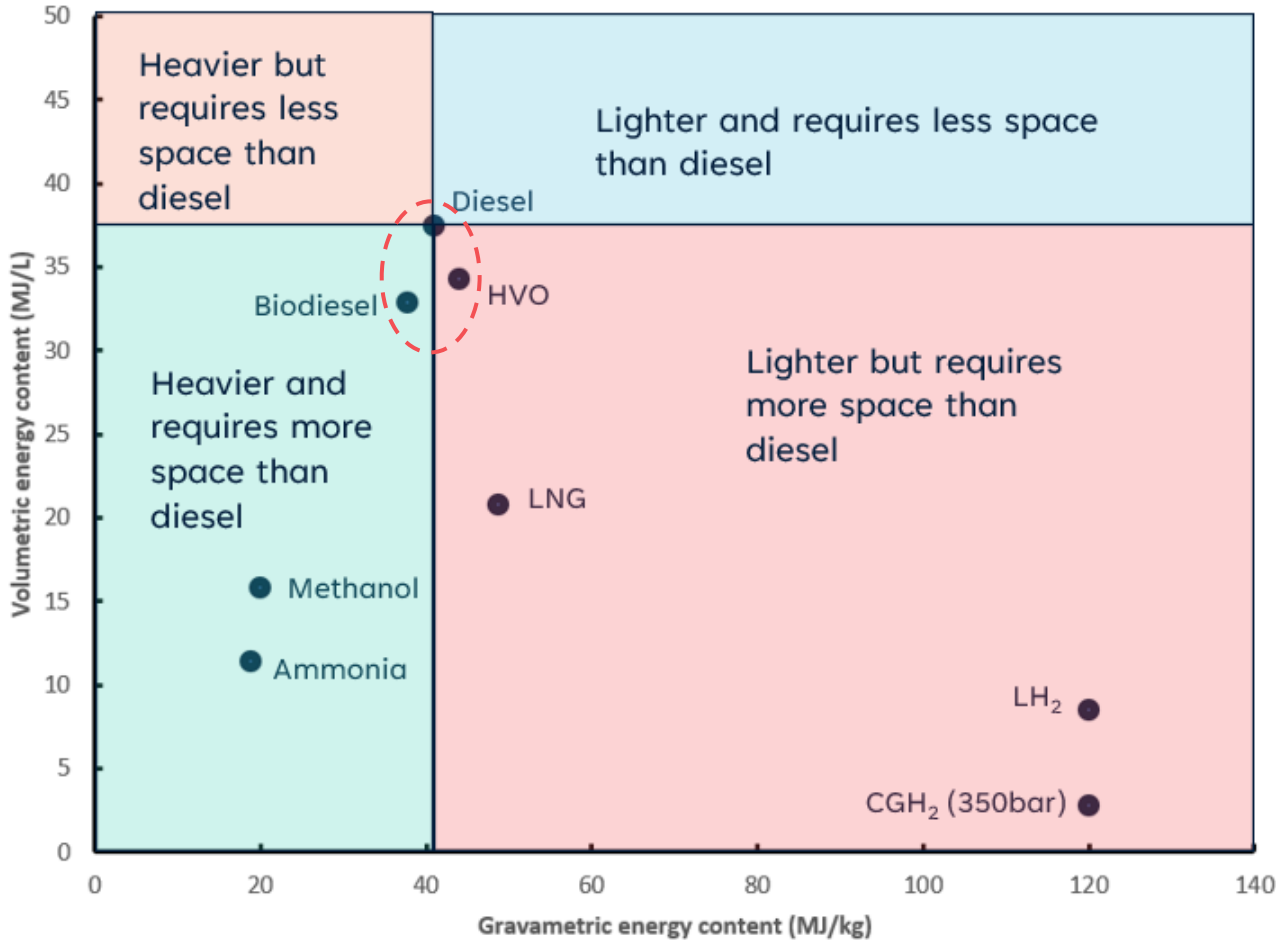


OEUK

North Sea Transition Authority

Why alternative diesels

- The only alternative fuel with similar gravimetric and volumetric energy content to fossil diesel
- Compatible with the majority of existing equipment that operate on diesel
- Significant reduction in GHG emissions on a lifecycle basis



Alternative diesel

Biodiesel (FAME - Fatty Acid Methyl Ester)
- Transesterification

HVO (Hydrotreated Vegetable Oil)/Green Diesel/Renewable Diesel
- Hydrogenation and hydrocracking

E-diesel
- Power-to-liquid fuels (Fischer-Tropsch)

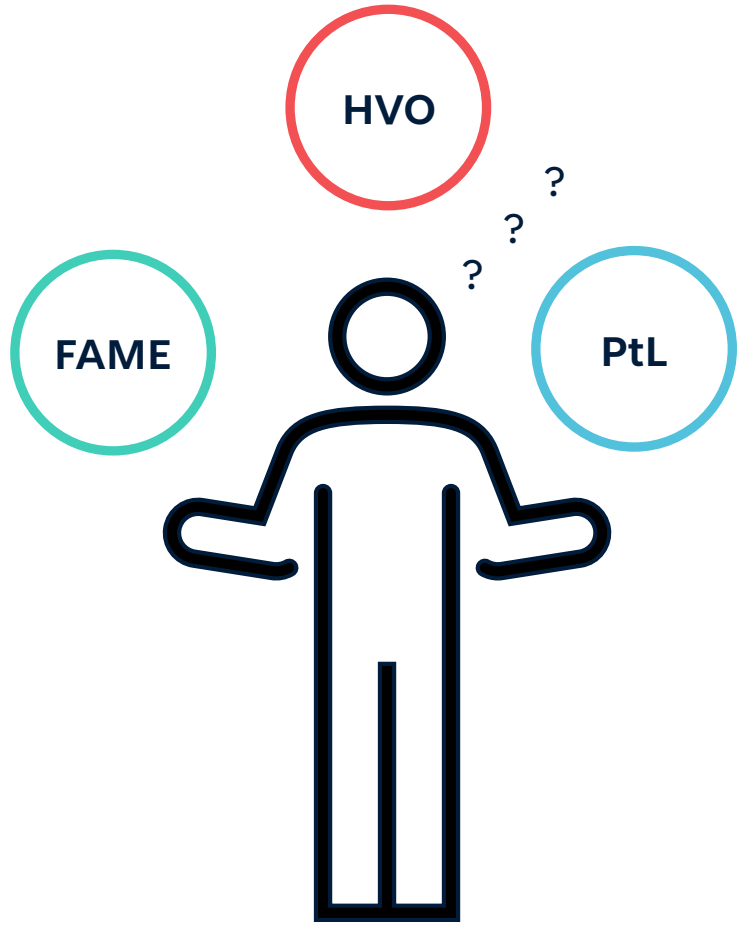
Advanced biodiesel
- GM crop bases
- Microbial production

Focus on HVO

- Properties of FAME make it unsuitable:
  - Cold weather performance
  - Gradual degradation of fuel
- eFuels (PtL) are currently only produced in small quantities and are very expensive

So why HVO:

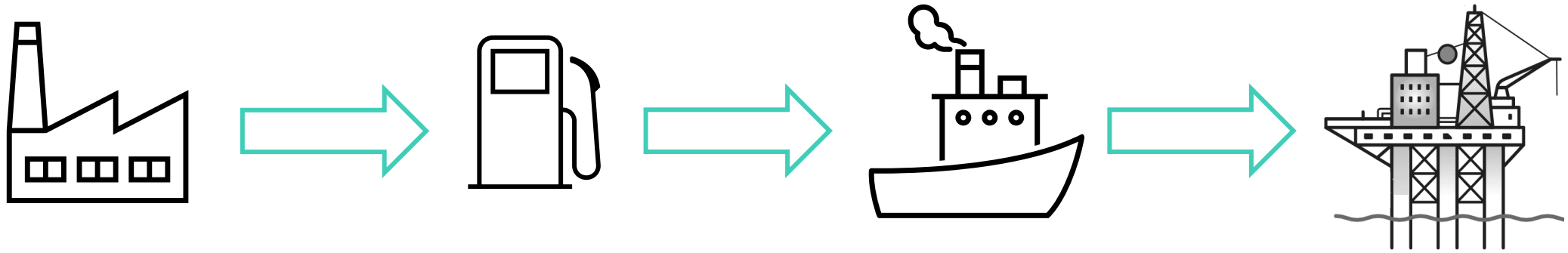
- Conforms to EN15940 and approved by numerous OEMs
- Performance similar to fossil diesel
- Up to 10-year shelf life – no oxygen content
- Can be blended with fossil diesel



Supply chain

Production

Transportation offshore

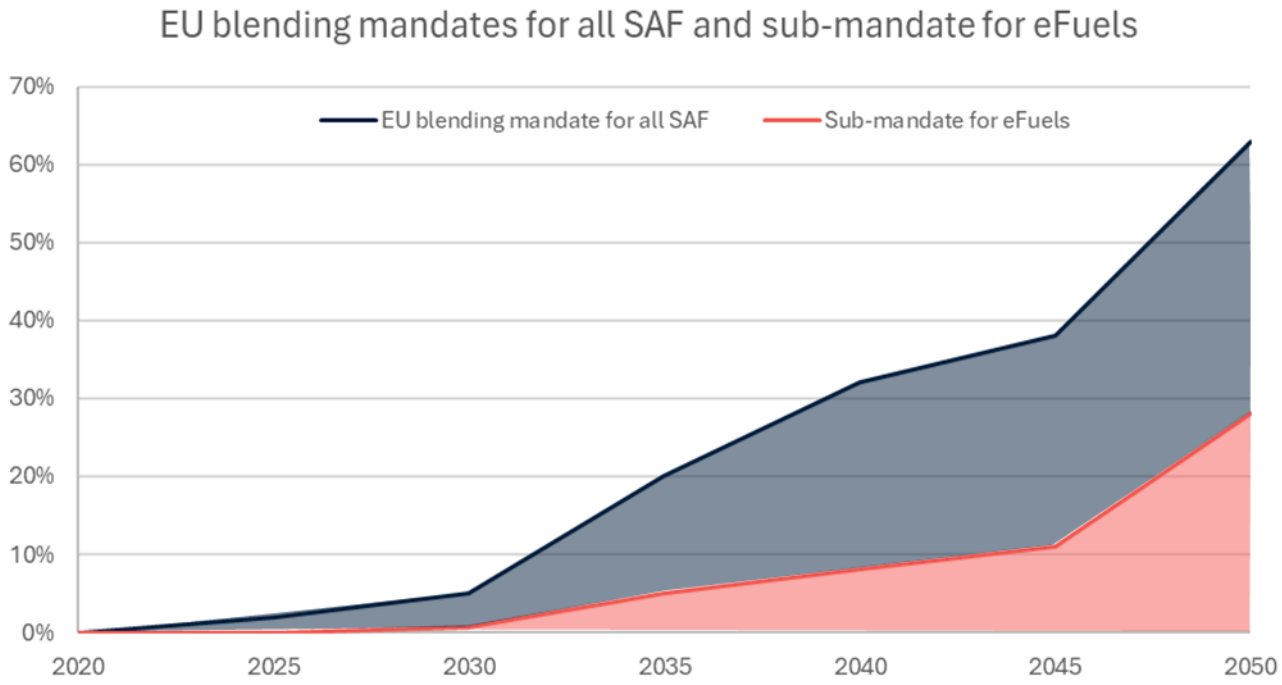


Onshore logistics

Offshore use

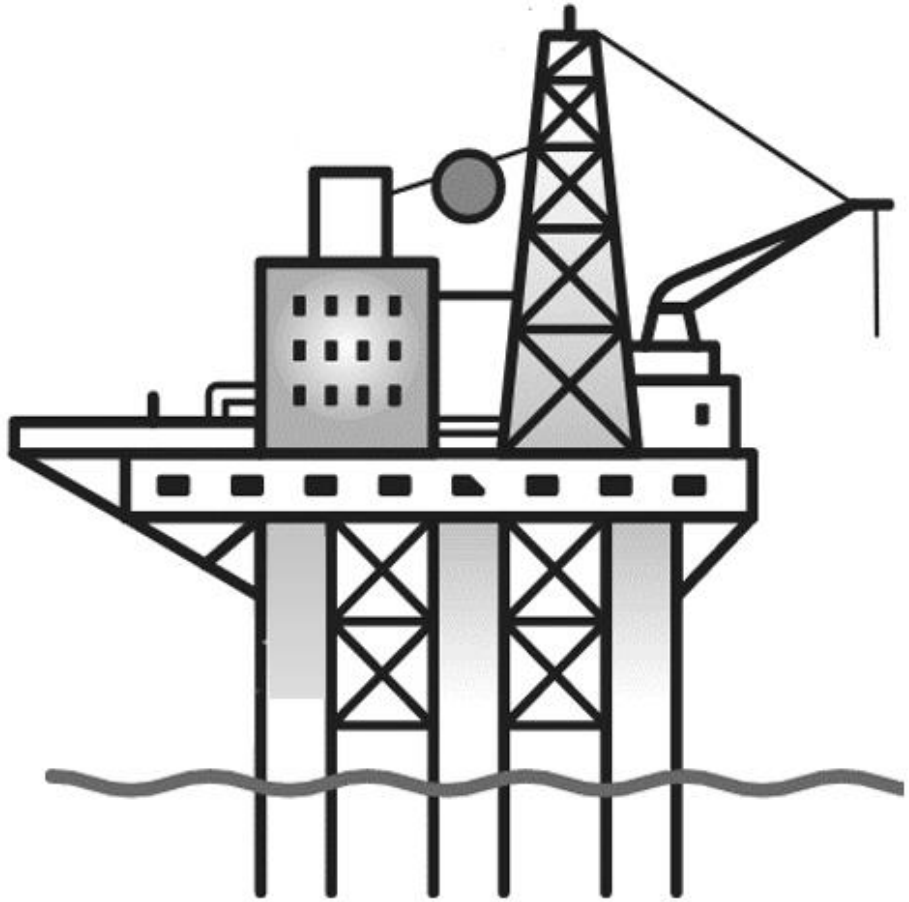
Competition from other industries

- Different industries are competing for the same fuels and feedstocks to make other renewable fuels
- The aviation sector is a prime example of this with mandates in place for the use of renewables fuel
- Forecasted 2030 EU jet fuel demand is 46 million tonnes with 2.3 million tonnes having to be SAF
- SAF production utilises identical feedstocks required for the production of renewable diesel



Oil and gas opportunities

- Assets that are deficient of fuel gas
- Temporary generators during TARs
- Temporary power generation on assets that have reached COP
- Replacing current diesel use
- Replacing fossil diesel use of drill rigs
- Onshore terminals



Challenges

Bio feedstock availability

Competition from other industries

Green electrons

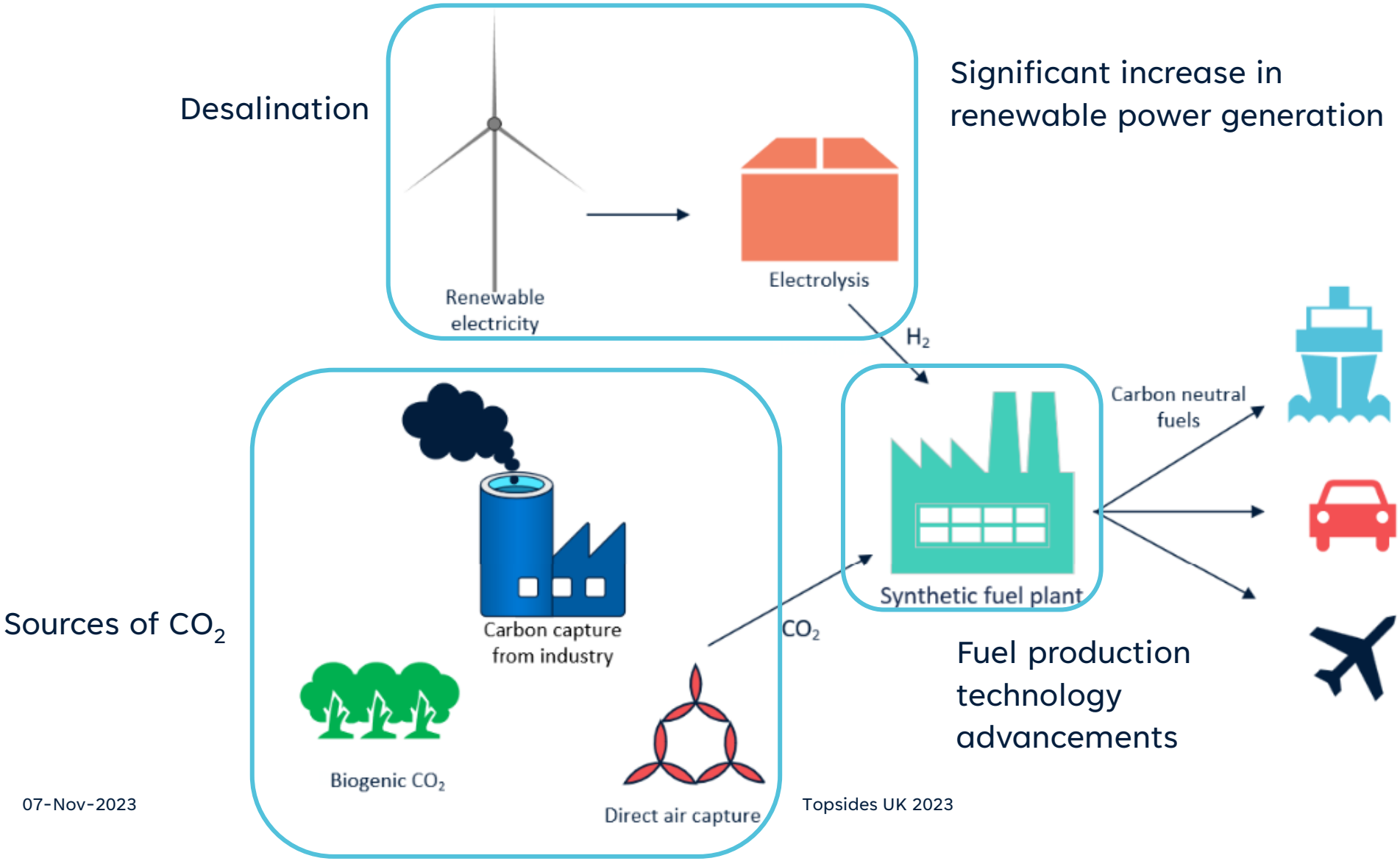
Costs

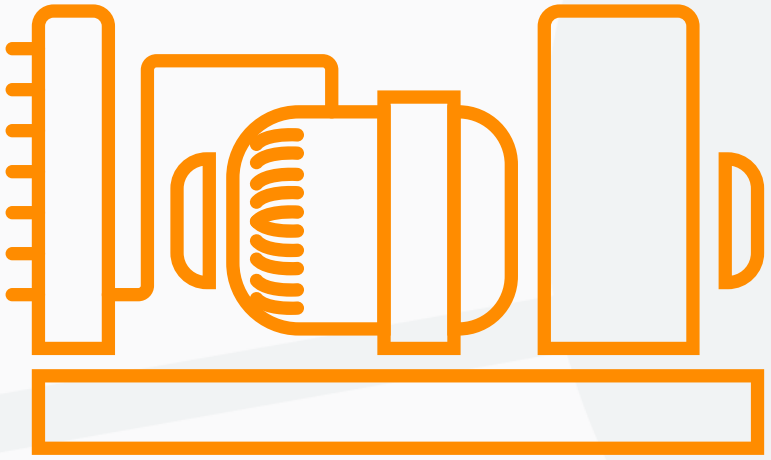
CO_2 source

Supply

Sustainability

Scale up scenario – what's needed





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