DIRECT CONVERSION OF CO_2 TO CARBON NEUTRAL FUELS

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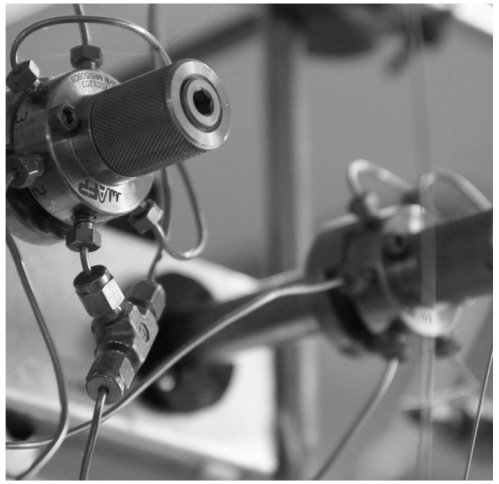
RESEARCH THEMES

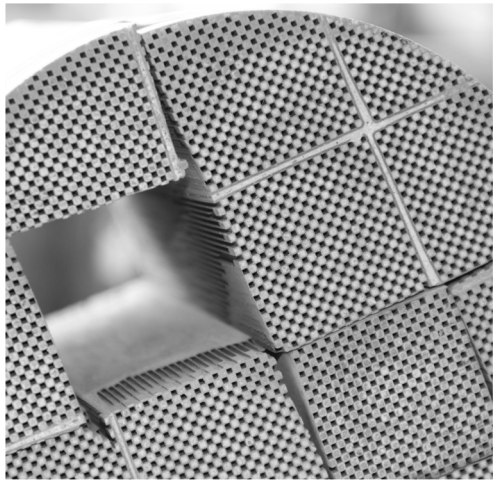
CATALYSTS FOR ENERGY

TECHNOLOGIES FOR GENERATING CARBON NEUTRAL PLATFORM CHEMICALS AND BIOFUEL FROM WASTE CARBON DIOXIDE FROM BIOGAS AND RENEWABLE HYDROGEN



REACTION ENGINEERING AND AFTERTREATMENT CATALYTIC TECHNOLOGIES

COMPREHENSIVE AND INTERDISCIPLINARY APPROACH WHERE DIFFERENT EXPERIMENTAL TECHNIQUES ARE SIMULTANEOUSLY APPLIED AND RECONCILED WITH STATE-OF-THE-ART INSIGHTS FROM THEORY AT THE DIFFERENT CHARACTERISTIC TIME SCALE.



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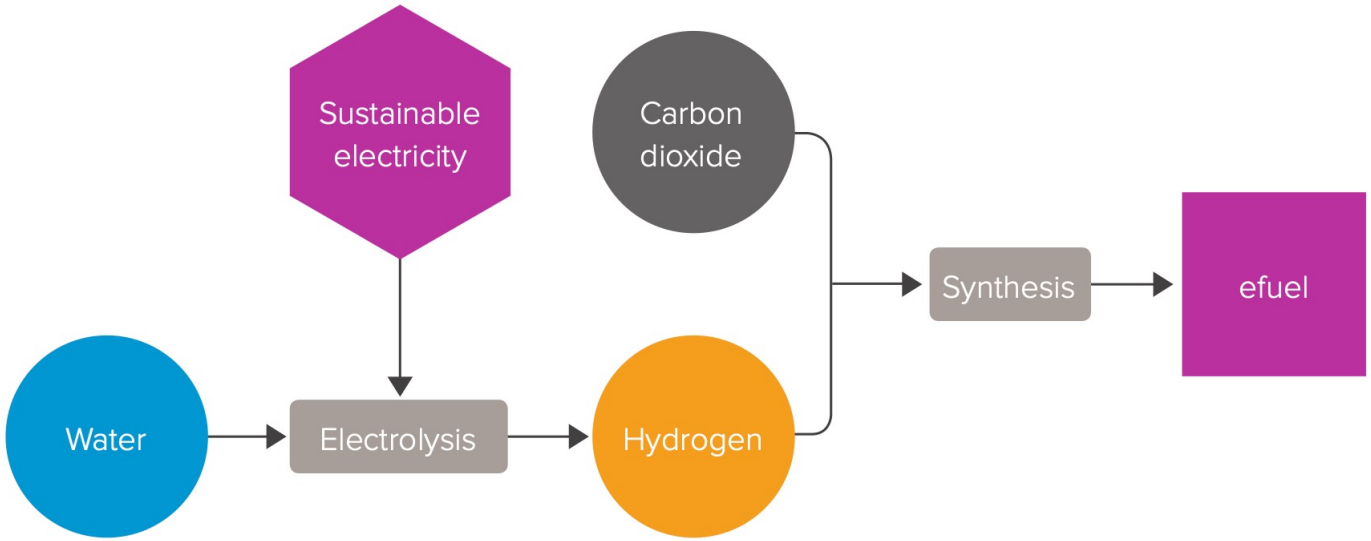

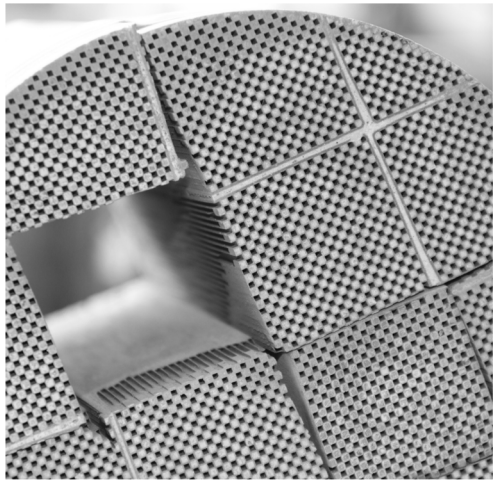

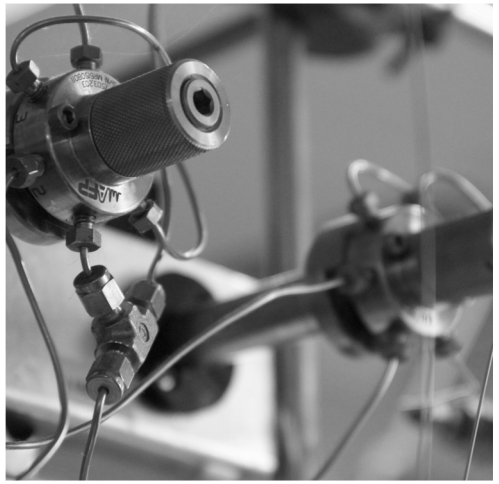

THE INDUSTRIAL NEED

SUSTAINABLE TRANSPORTATION

new fuel for trucks

- clean
- powerful
- easy to produce from local waste residues and get to zero-emission

HYDROGEN CARRIER

new hydrogen carrier

- high energy density
- efficient production
- safe storage and delivery

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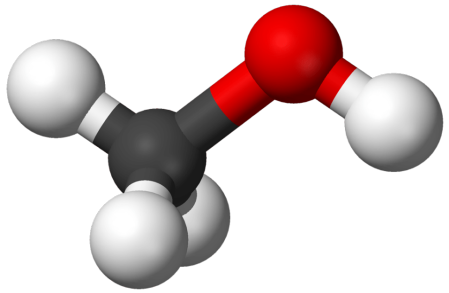
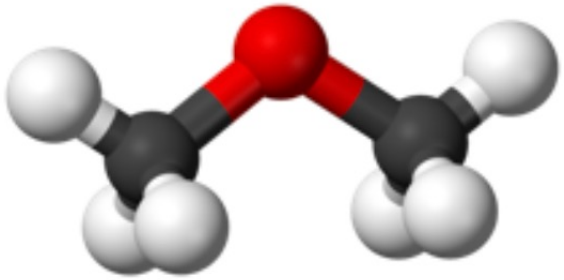
METOH



DME



SUSTAINABLE TRANSPORTATION

DIESEL-LIKE PERFORMANCE

- High cetane number of 55
- Engines with low maintenance costs
- Compression ignited with high efficiency
- No spark plugs

SAFE

- Non-toxic
- Safe, rapid, low pressure dispensing
- Spillage will not contaminate soil

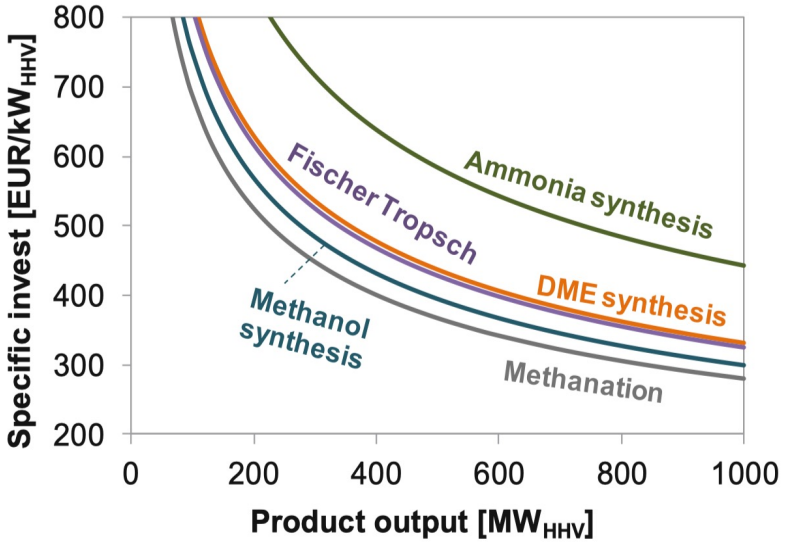
CLEAN-BURNING

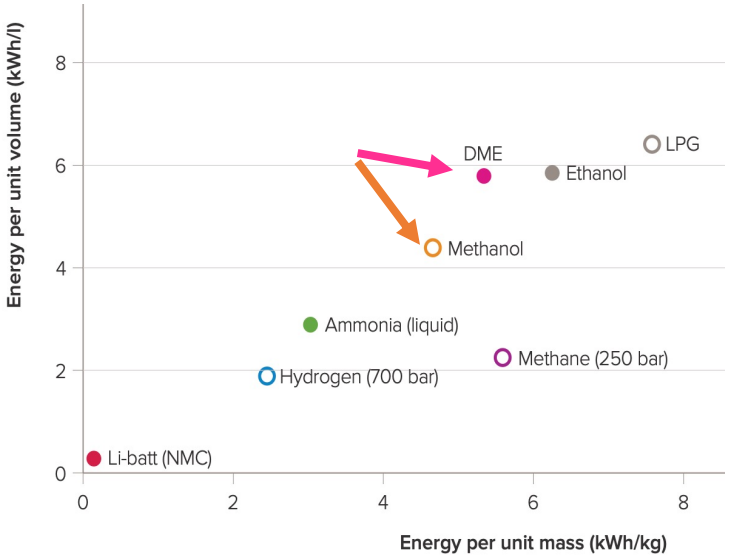
- Burns with no particulate matter
- Sulfur-free
- Low NOx emission
- Meets or exceeds strict emissions standards

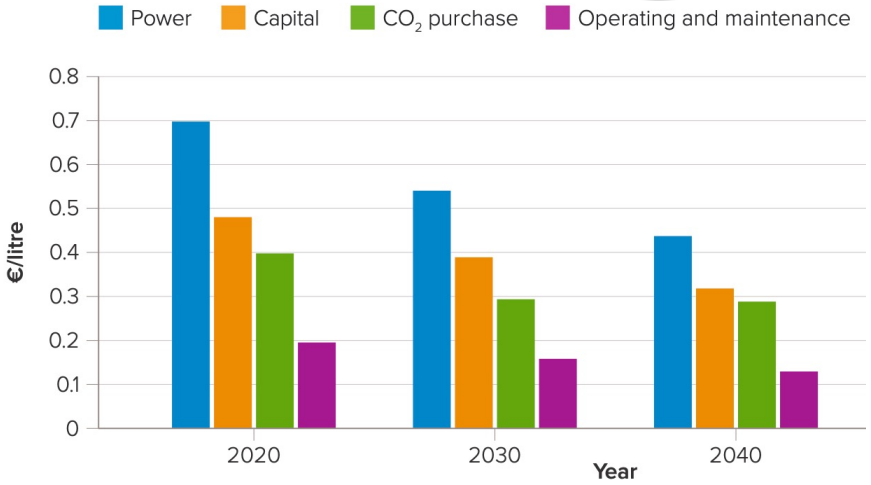
PRICE COMPETITIVE

- Price competitive with that of diesel
- Due to DME's simplicity, lower or competitive total cost of ownership with diesel vehicles

COMPETITIVE ADVANTAGES OF METHANOL AND DME







POWER-TO-FUEL TECHNOLOGIES

Excellent balance between investment costs and production costs compared to other power-to-fuel technologies

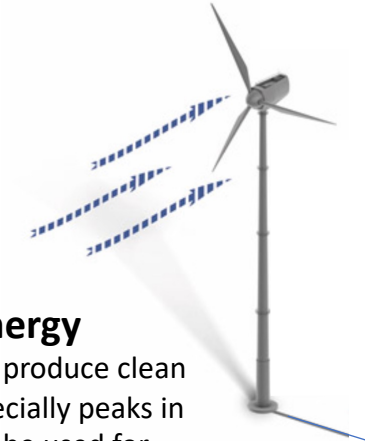
SPECIFIC ENERGY AND ENERGY DENSITY

DME as energy vector has a much higher energy density than methanol, methane and hydrogen

CAPEX / OPEX

The current cost of biofuels depends primarily on the cost of sustainable electricity and CO_2 purchase

DIRECT CONVERSION OF CO_2 TO BIOFUELS

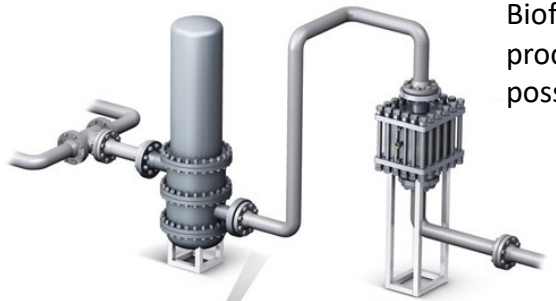


2. Clean energy

Windfarms can produce clean electricity; especially peaks in production can be used for electrolysis

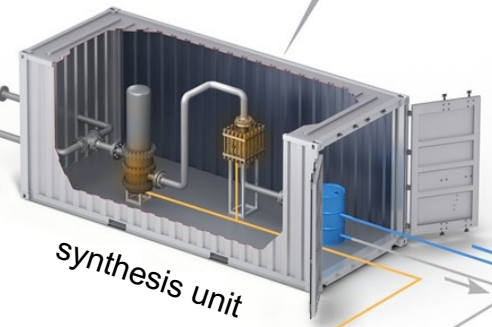
3. Electrolysis

Electrolysis splits water into hydrogen and oxygen



4. Synthesis

Biofuels are produced in a 2-stage process; skid-mounted units are possible.



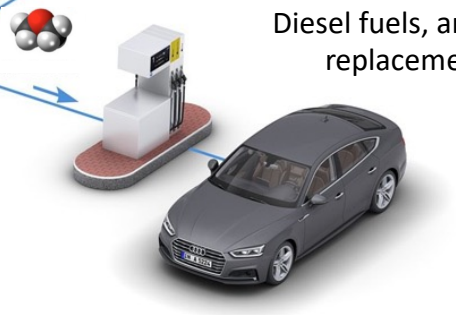
1. CO_2 emissions

Biogas plants produce CO_2 and methane; the CO_2 can be separated

Biogas (AD) plant

5. Infrastructure compatibility

Bio-Methanol or DME is compatible with Diesel fuels, and can either be used as replacement or additive to reduce emissions

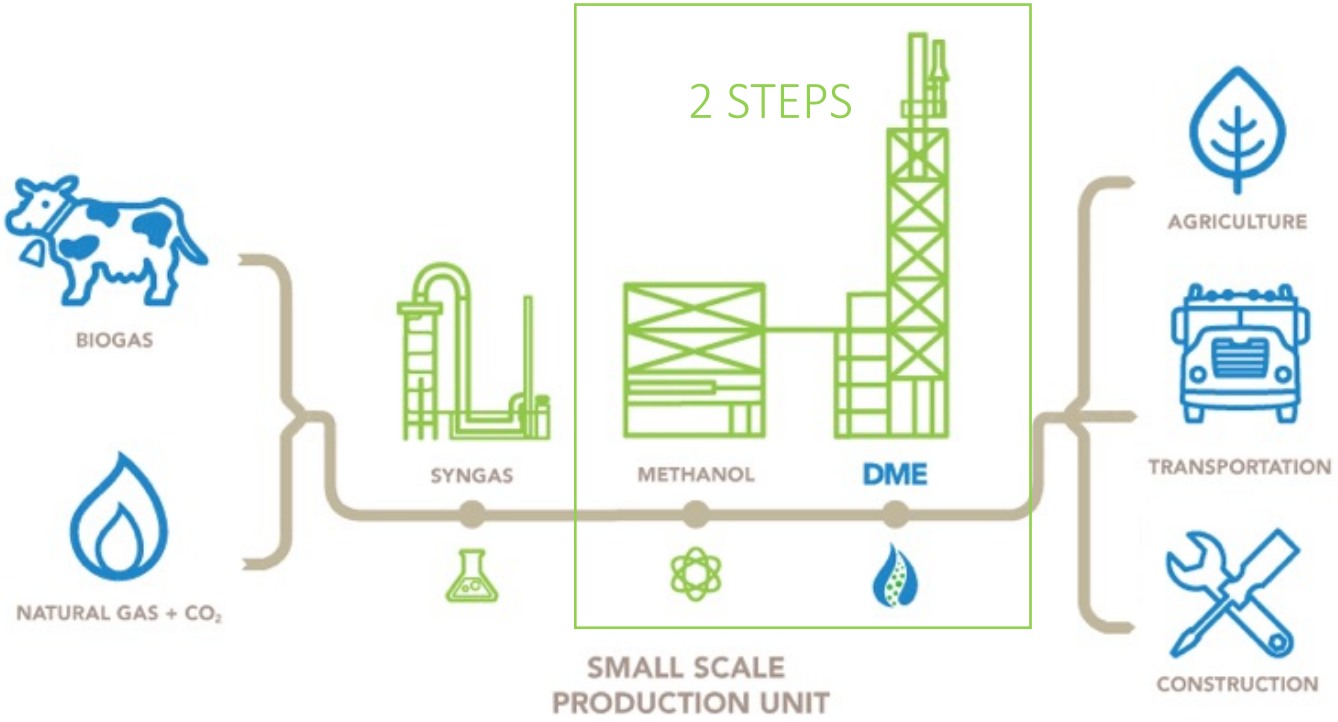


Heat for use in residential areas, in generators or in industry.

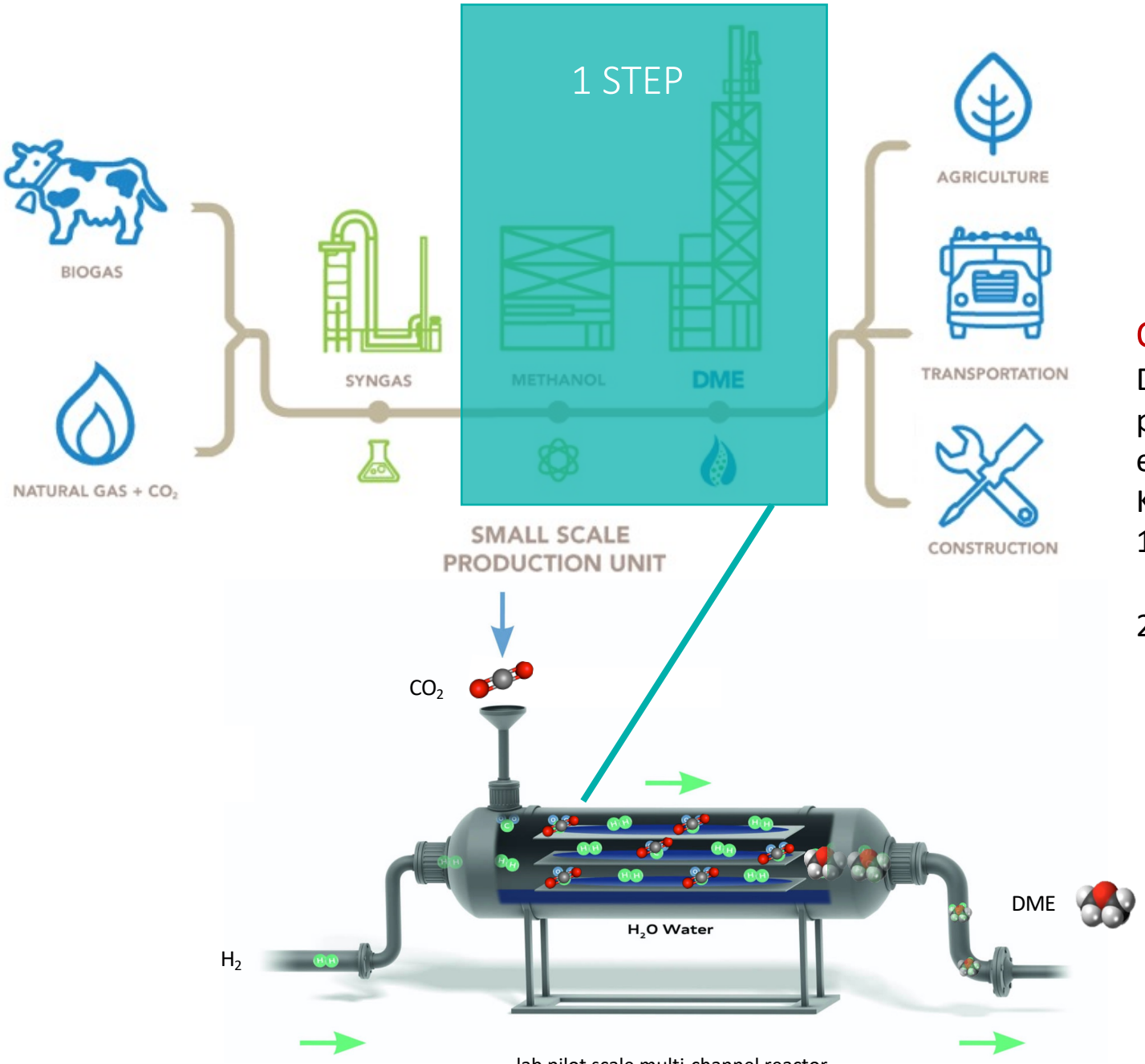
6. Applications in industry

Clean truck fuels, carbon-neutral ship fuels and additives, solvents, generators

INNOVATION


2 STEPS
BIOGAS
NATURAL GAS + CO_2
SYNGAS
METHANOL
DME
SMALL SCALE
PRODUCTION UNIT
AGRICULTURE
TRANSPORTATION
CONSTRUCTION

INNOVATION



lab pilot scale multi-channel reactor

ONE-STEP PROCESS

Direct conversion of CO_2 to products thermodynamically and economically advantageous

Key reactions:

1) hydrogenation of CO_2 to methanol
2) methanol dehydration to DME

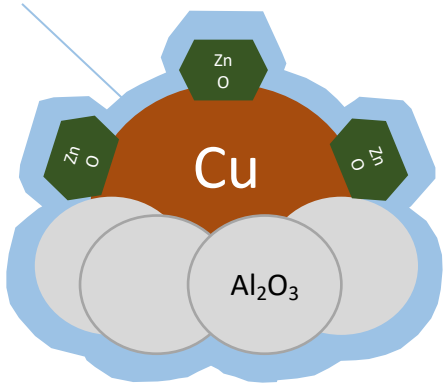
NEW HYBRID CATALYST FOR ONE-STEP PROCESS

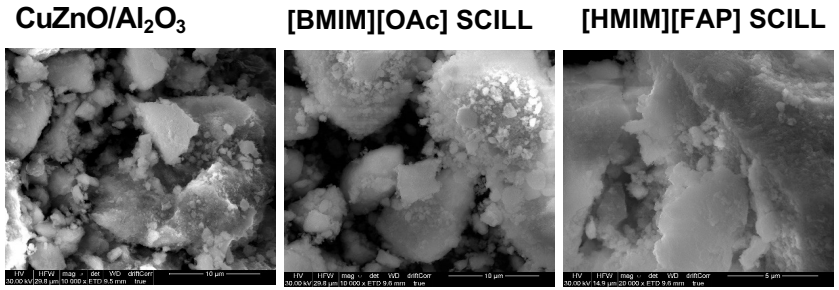
CATALYSTS FOR ENERGY

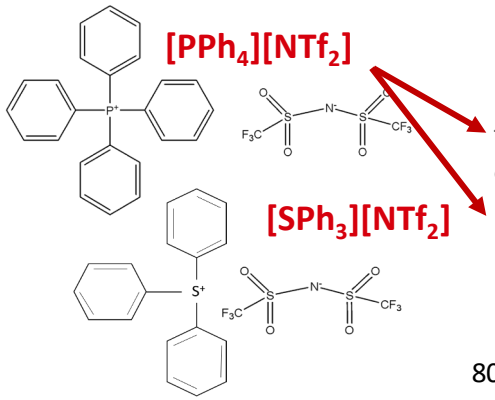
1. SOLID CATALYST WITH IL LAYER (SCILL) FOR DIRECT HYDROGENATION OF CO_2 TO METHANOL

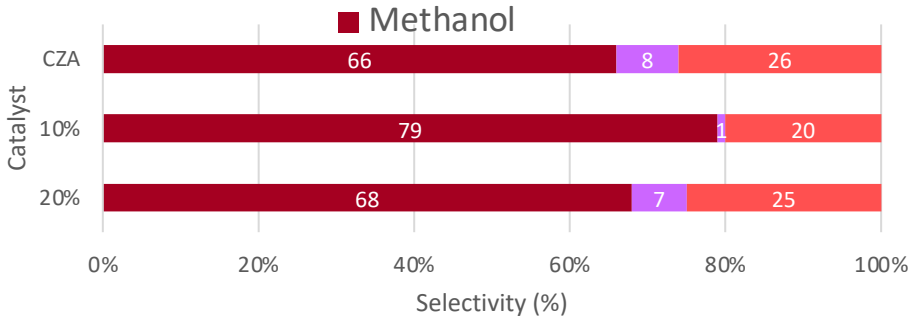
nanostructured Cu-ZnO-based catalyst and HZSM-5 zeolite as solid acid as the dehydration function

IL layer







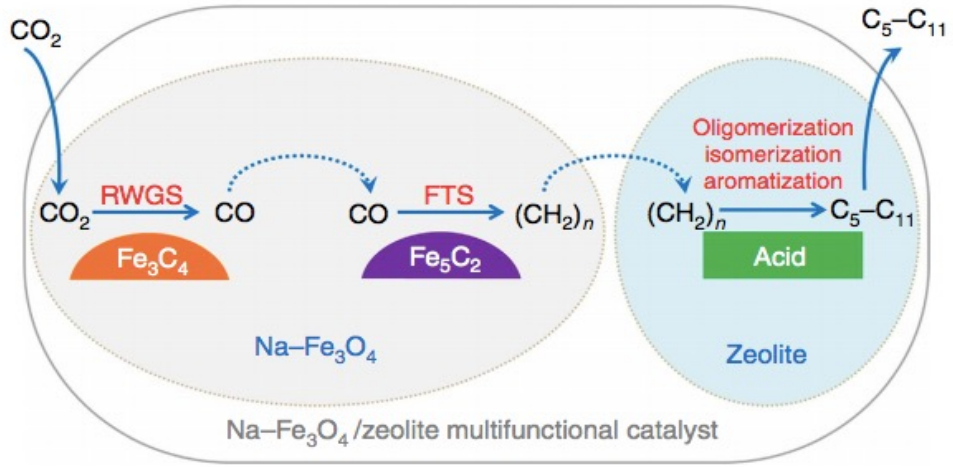


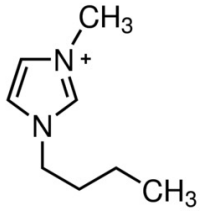
- High solubility of CO_2 in ionic liquids
- IL enhance yield of CO_2 transformations by thermodynamically favouring product formation
- IL stabilise intermediate species and the catalyst→ higher selectivity to Methanol

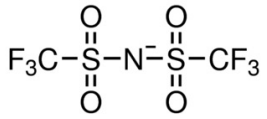
80% CO_2/H_2 (1:3), 20% N_2 Flow 50 Ncc/min 250 °C, 20 bar, GHSV 6000 $hour^{-1}$, conversion 10%

CATALYSTS FOR ENERGY

2. LIQUID PRECURSORS FOR NANOCATALYSTS PREPARATION FOR THE DIRECT CONVERSION OF CO_2 TO HYDROCARBONS



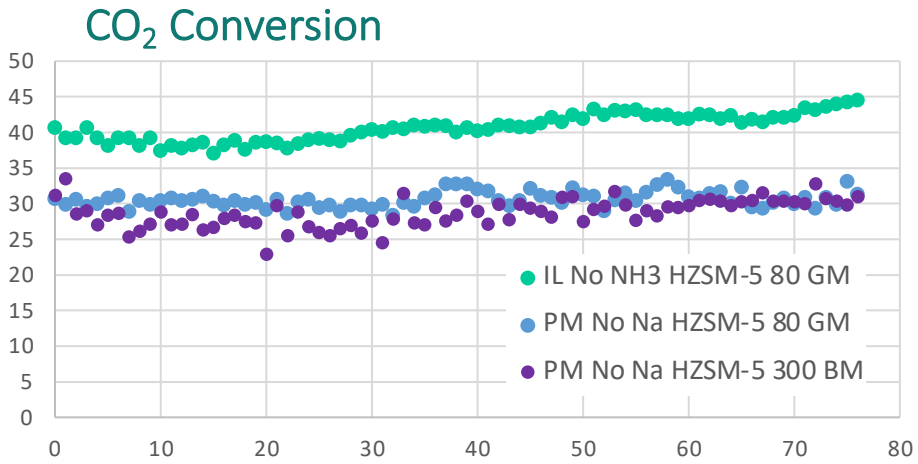




[bmim][Tf_2N]- Ionic liquid utilised in the high temperature solution-phase reaction (HTSP)

Fe_3O_4 nanoparticles *via* ionic liquid assisted synthesis method:

- Higher reducibility
- higher CO_2 conversion



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