CO_2 utilization:

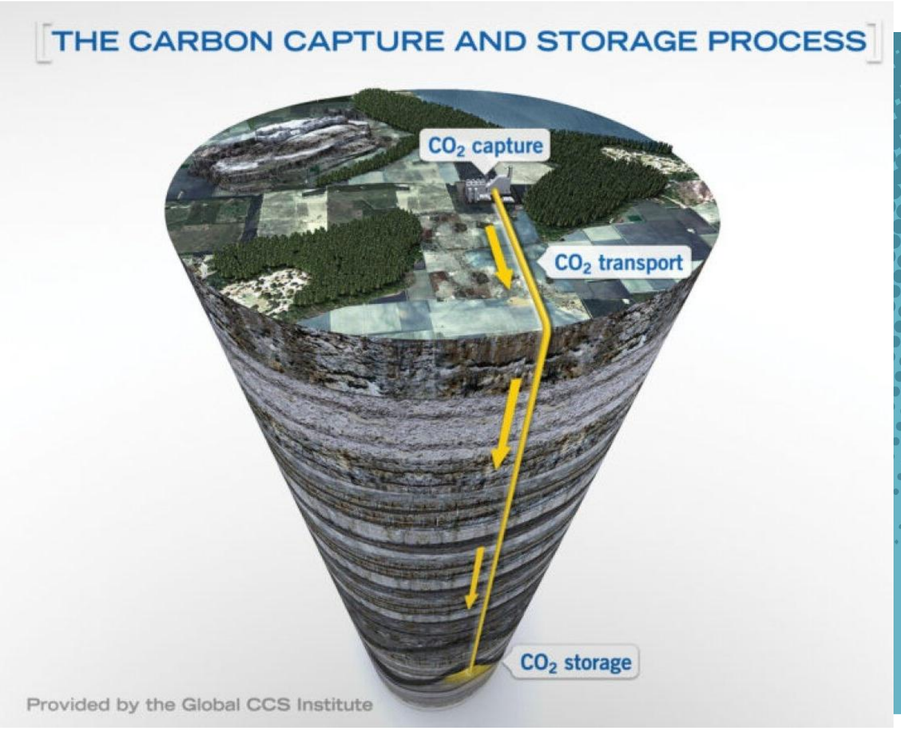
Does it make sense?

Earl Goetheer

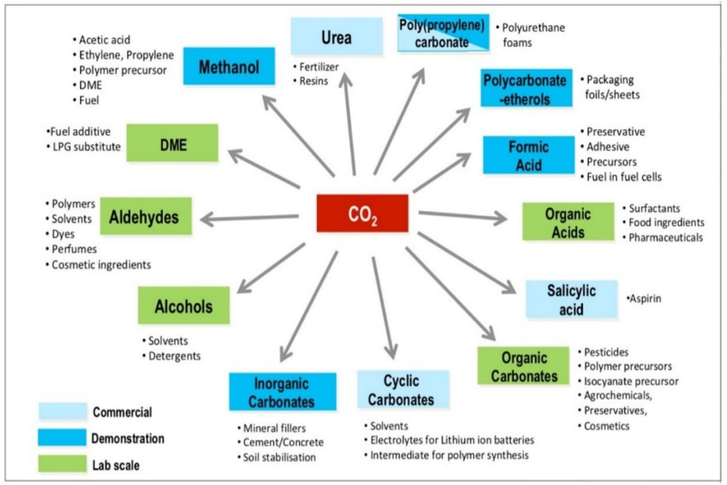
earl@hightechxl.com

Capturing CO2 is easy

The Main Question:
What do you do with the CO2?



- Recarbonisation

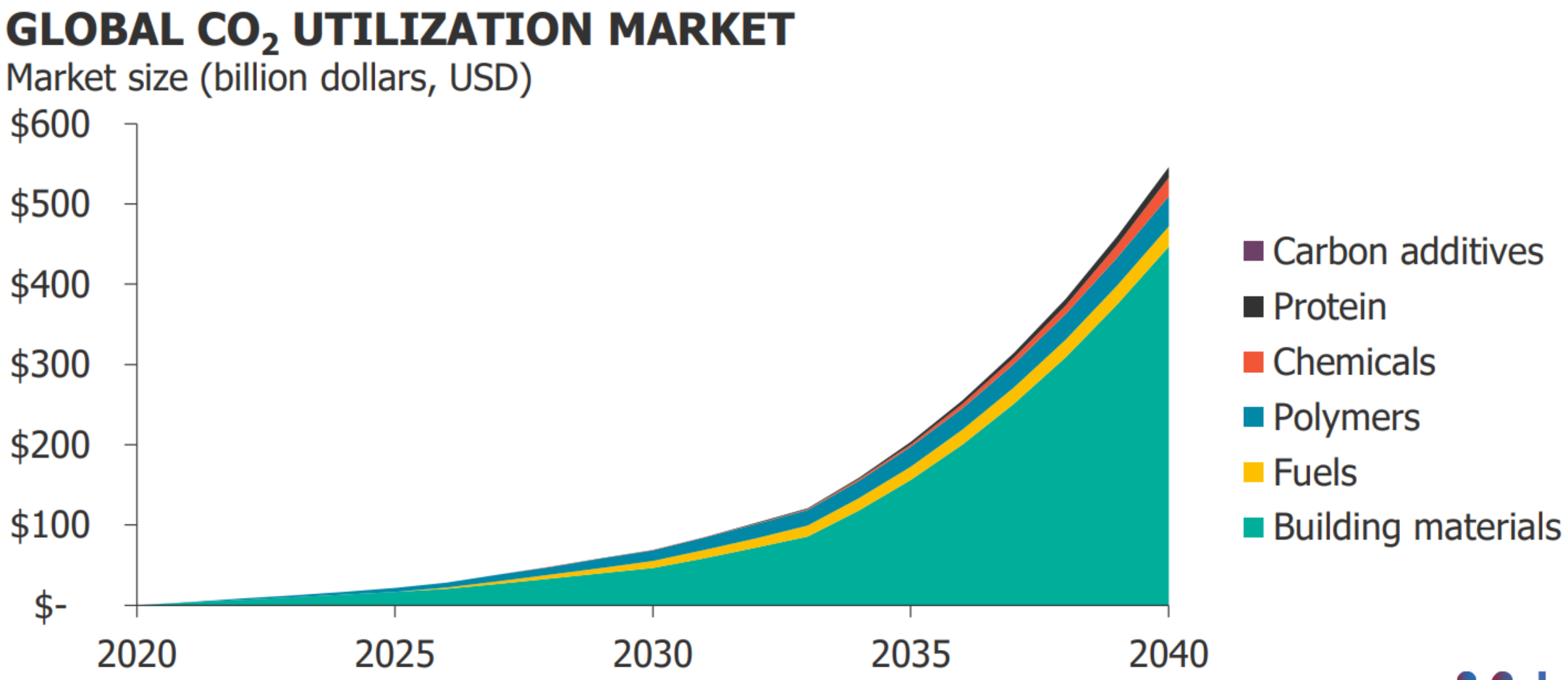


- Mineralization

EXECUTIVE SUMMARY

CO_2 utilization will be a $550 billion dollar market by 2040, driven by the building materials sector

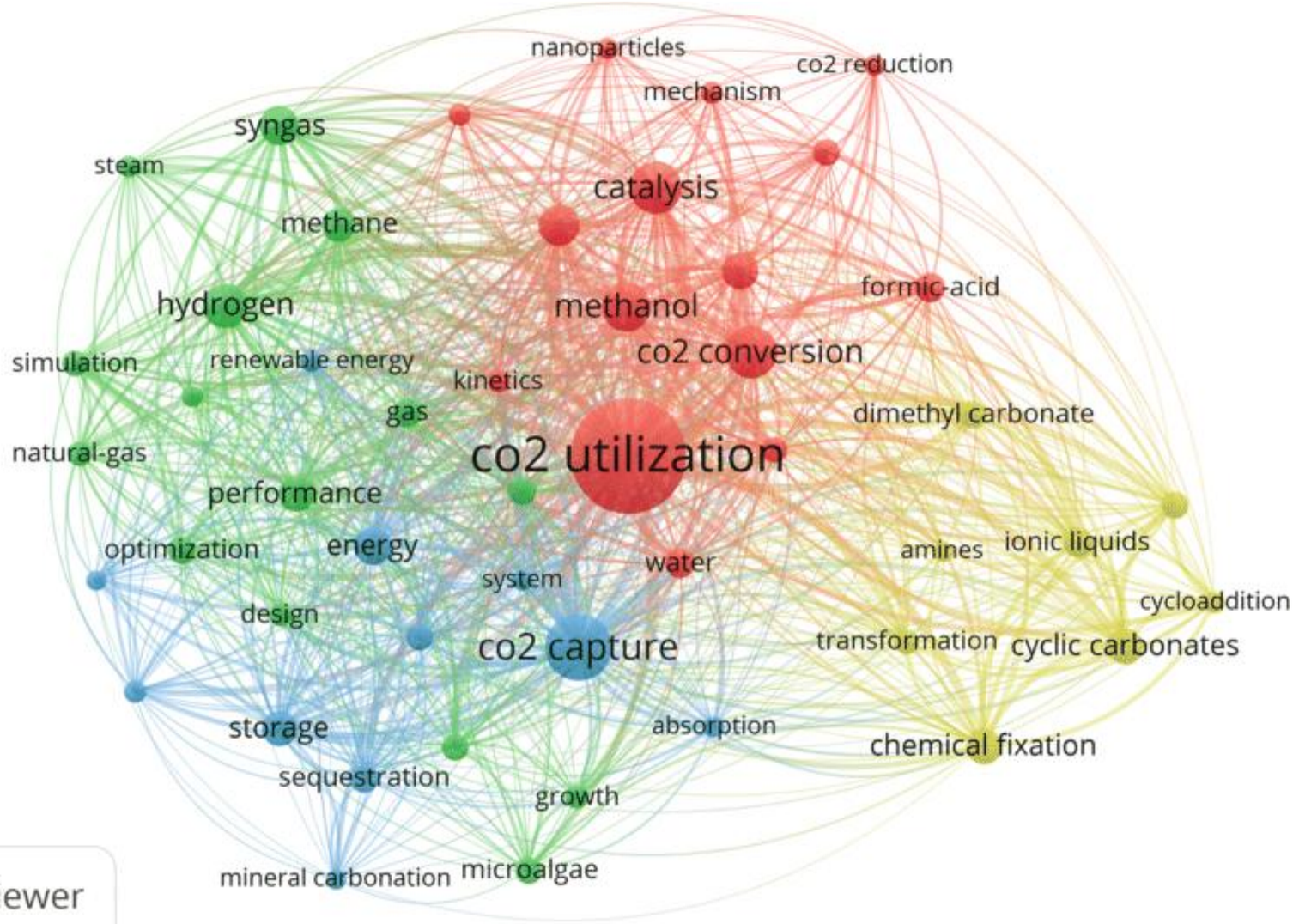
GLOBAL CO_2 UTILIZATION MARKET

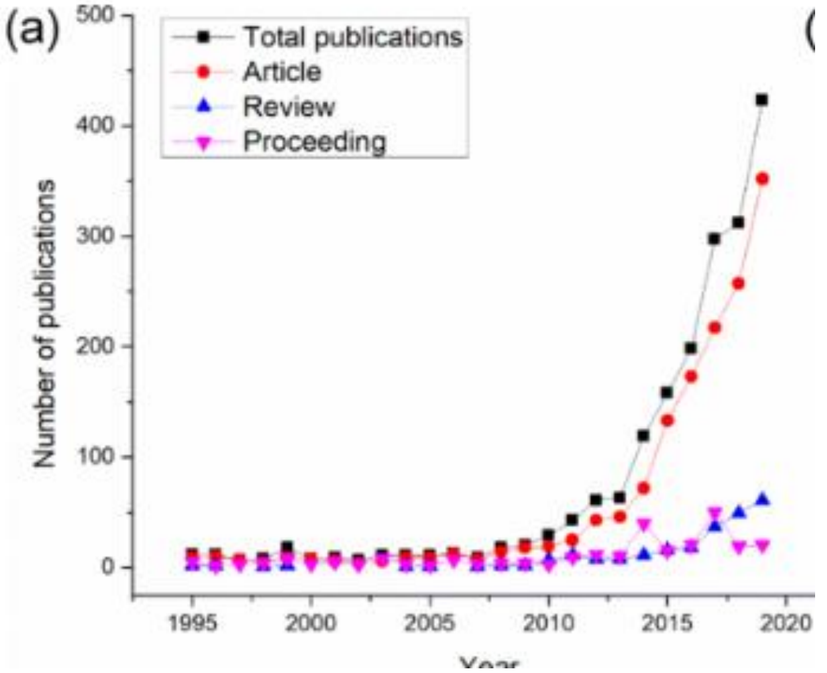


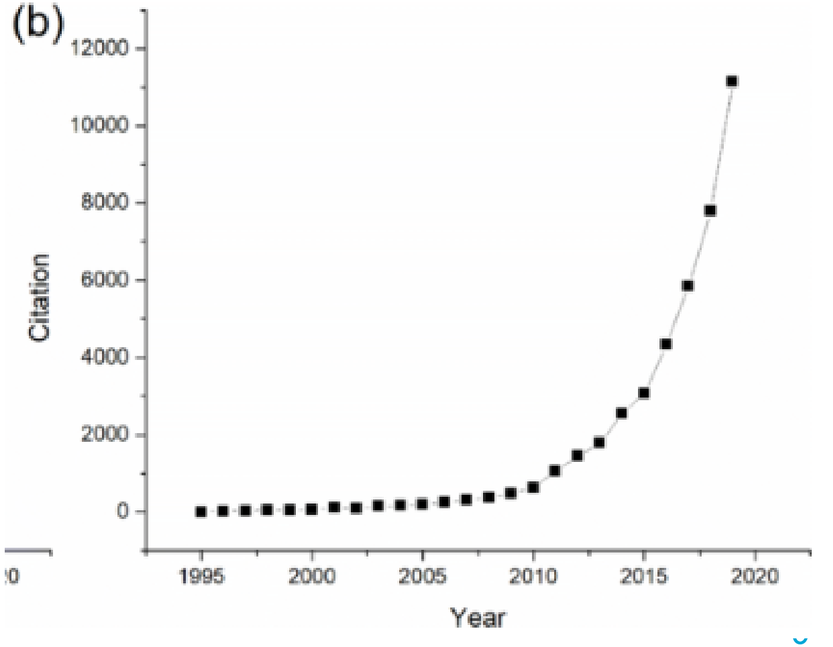
nt confidential. Not for redistribution.

Lux Research

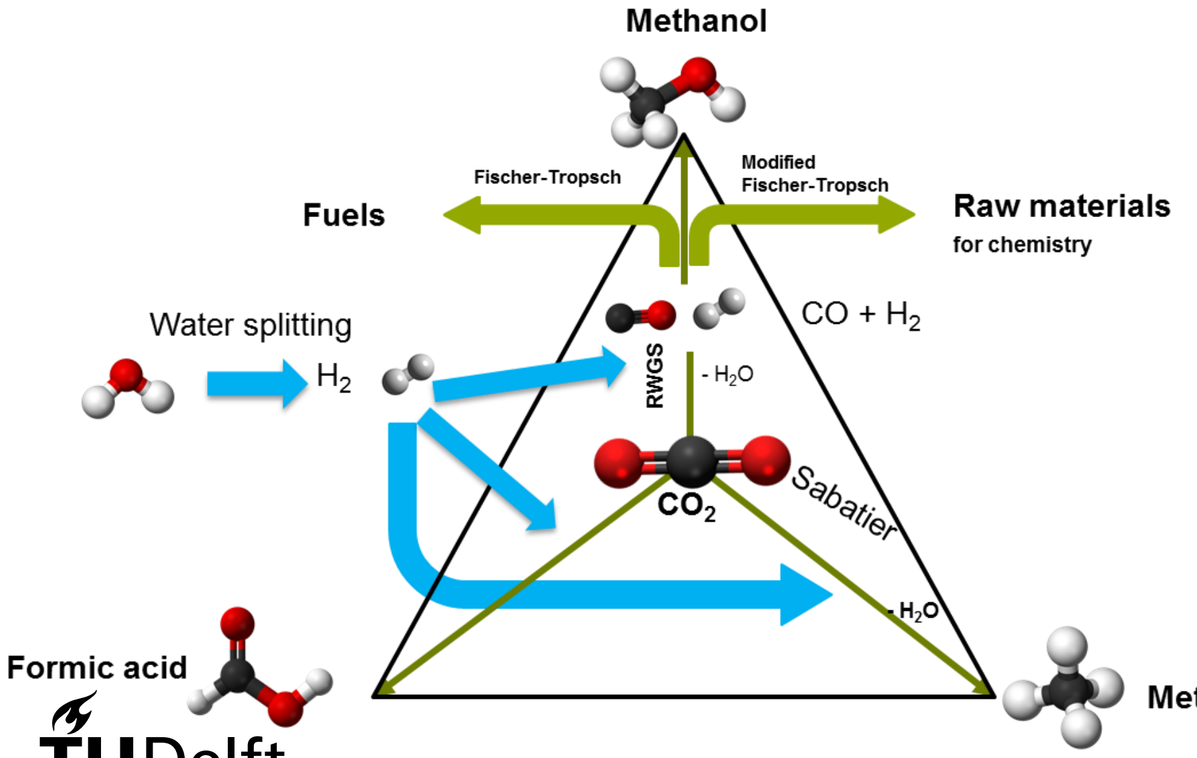
CO2 CONVERSION
SIGNIFICANT OF SCIENTIFIC INTEREST



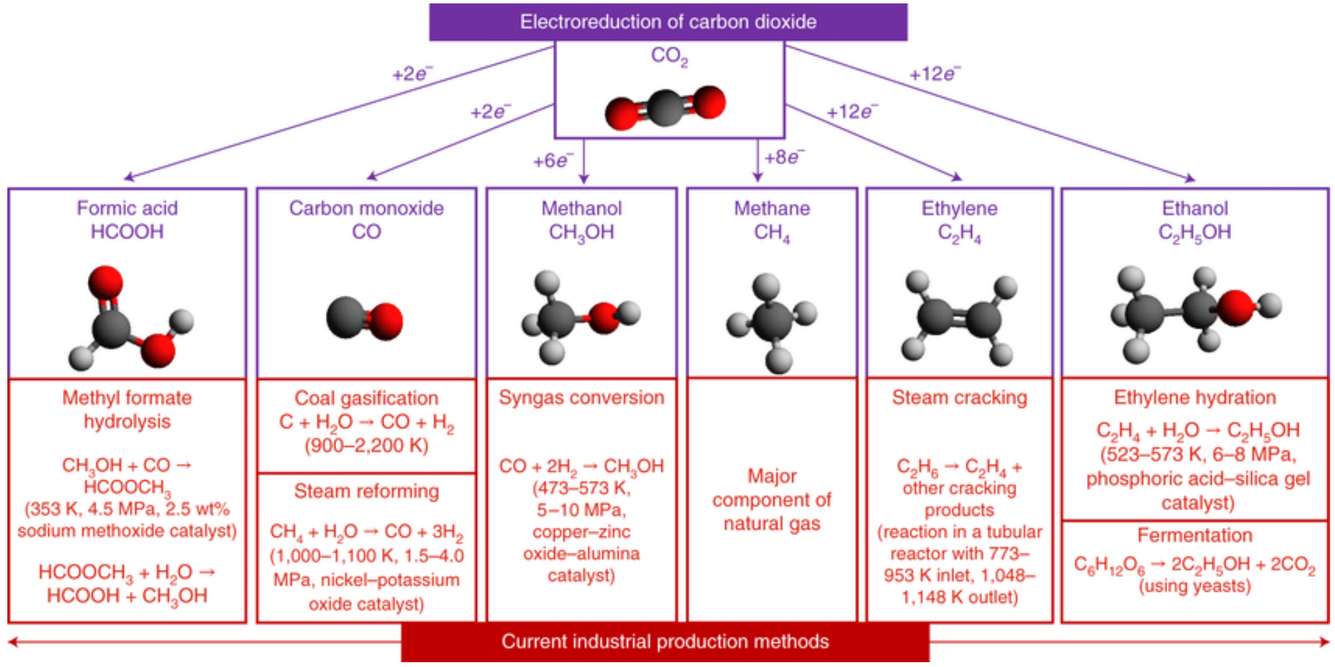




INDIRECT ROUTES (VIA H2)



Direct routes (electrochemistry)

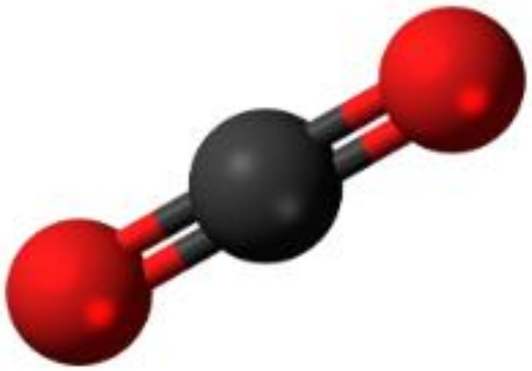


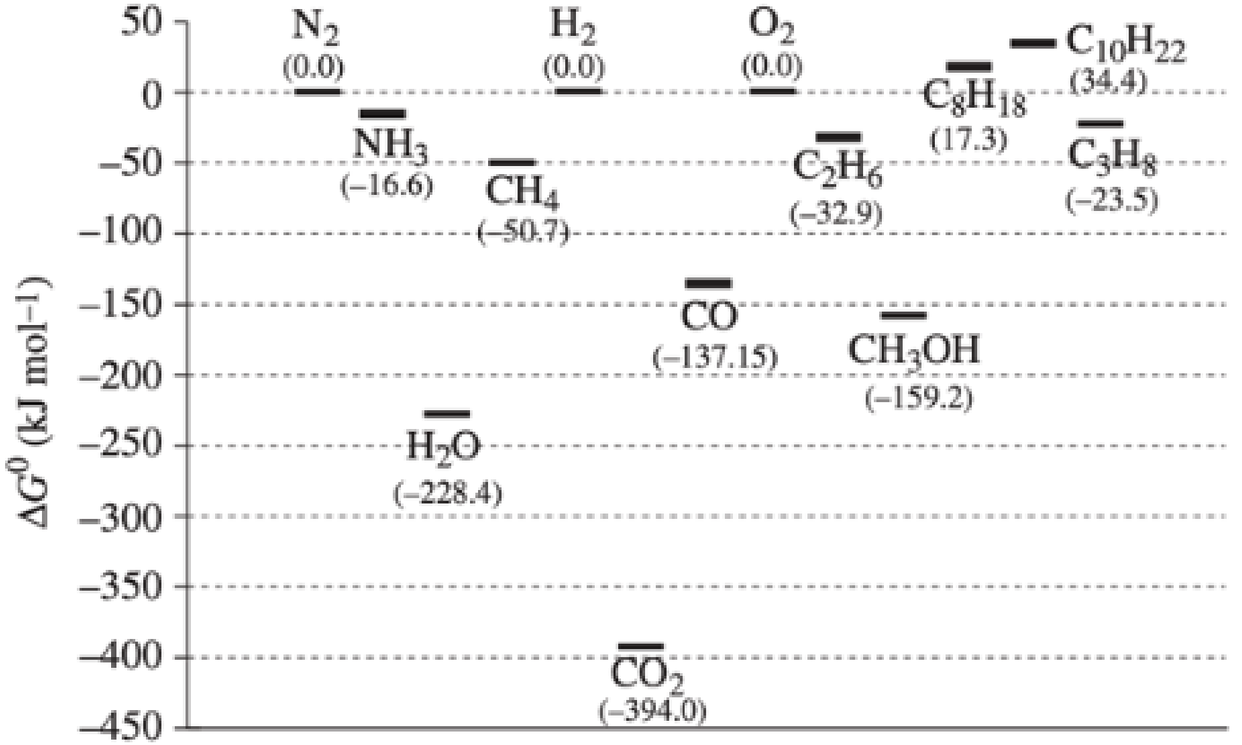
10.1038/s41560-019-0374-6.


YES, BUT...

FROM A THERMODYNAMIC PERSPECTIVE

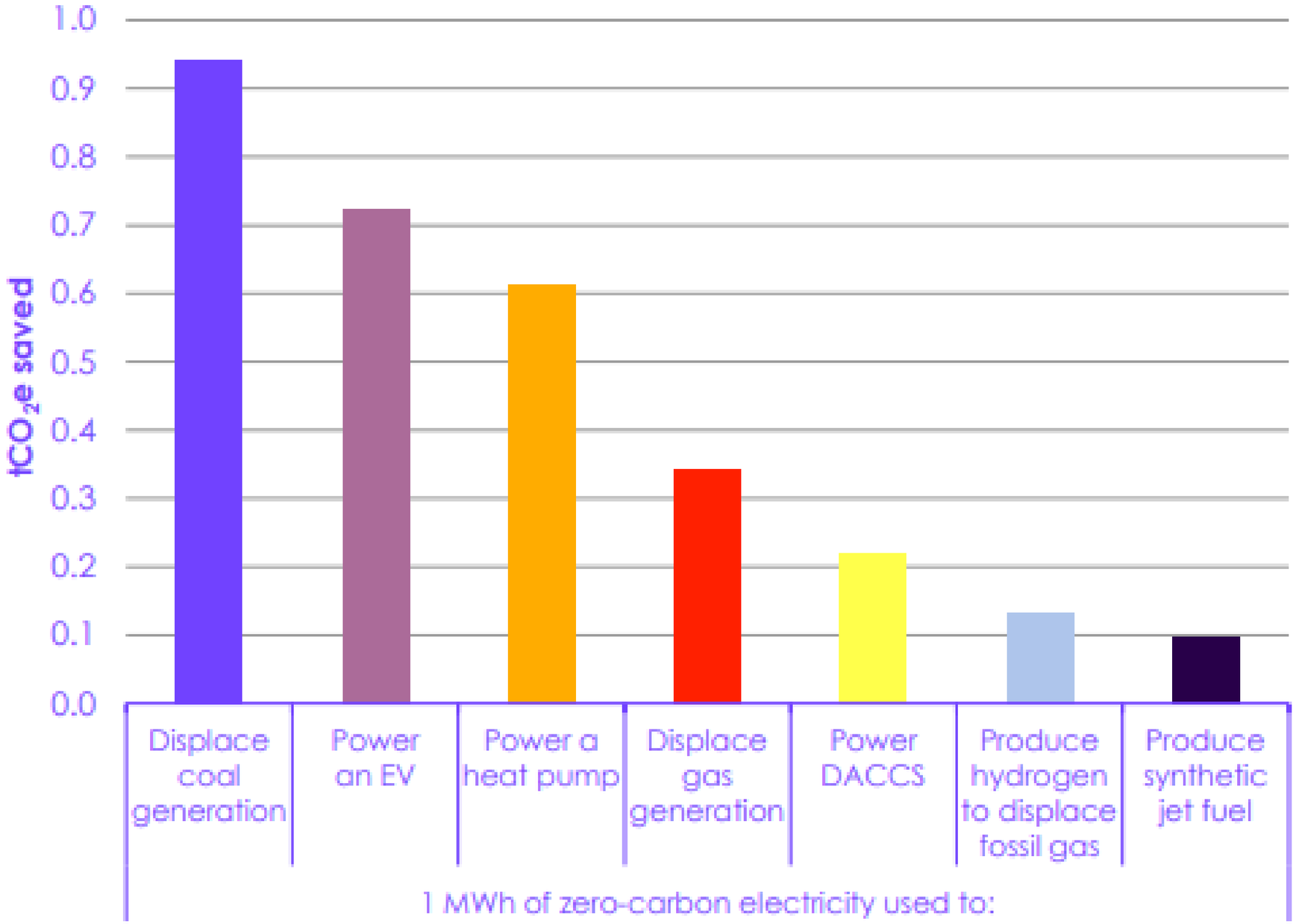
CO2 is 73 wt% O and is neither free nor pure





Z. Jiang, et al., *Phil. Trans. R. Soc. A*, 2010, **368**, 3343-3364.

EMISSIONS SAVED WITH 1 MWH OF ZERO-CARBON ELECTRICITY IN DIFFERENT APPLICATIONS

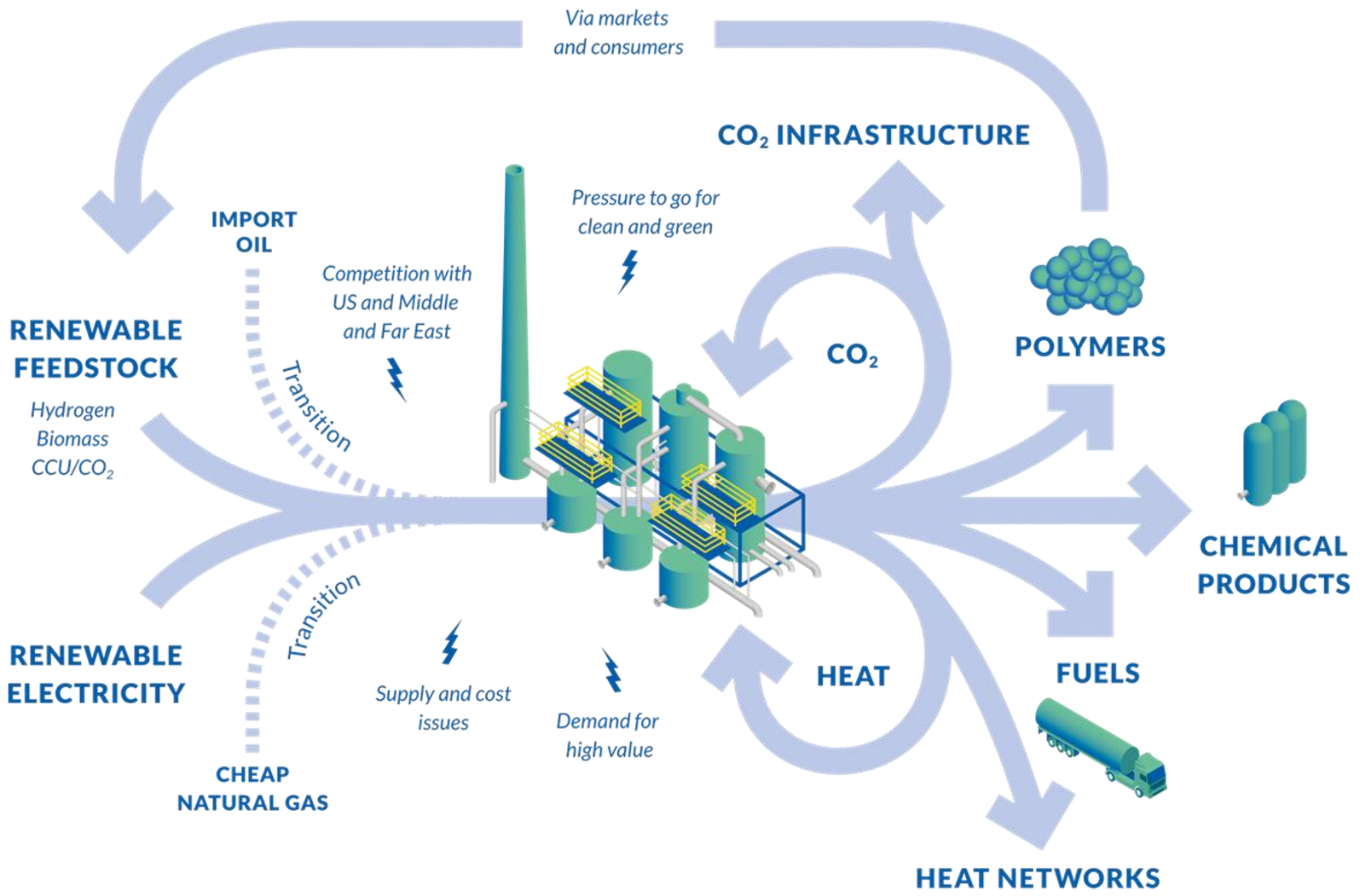


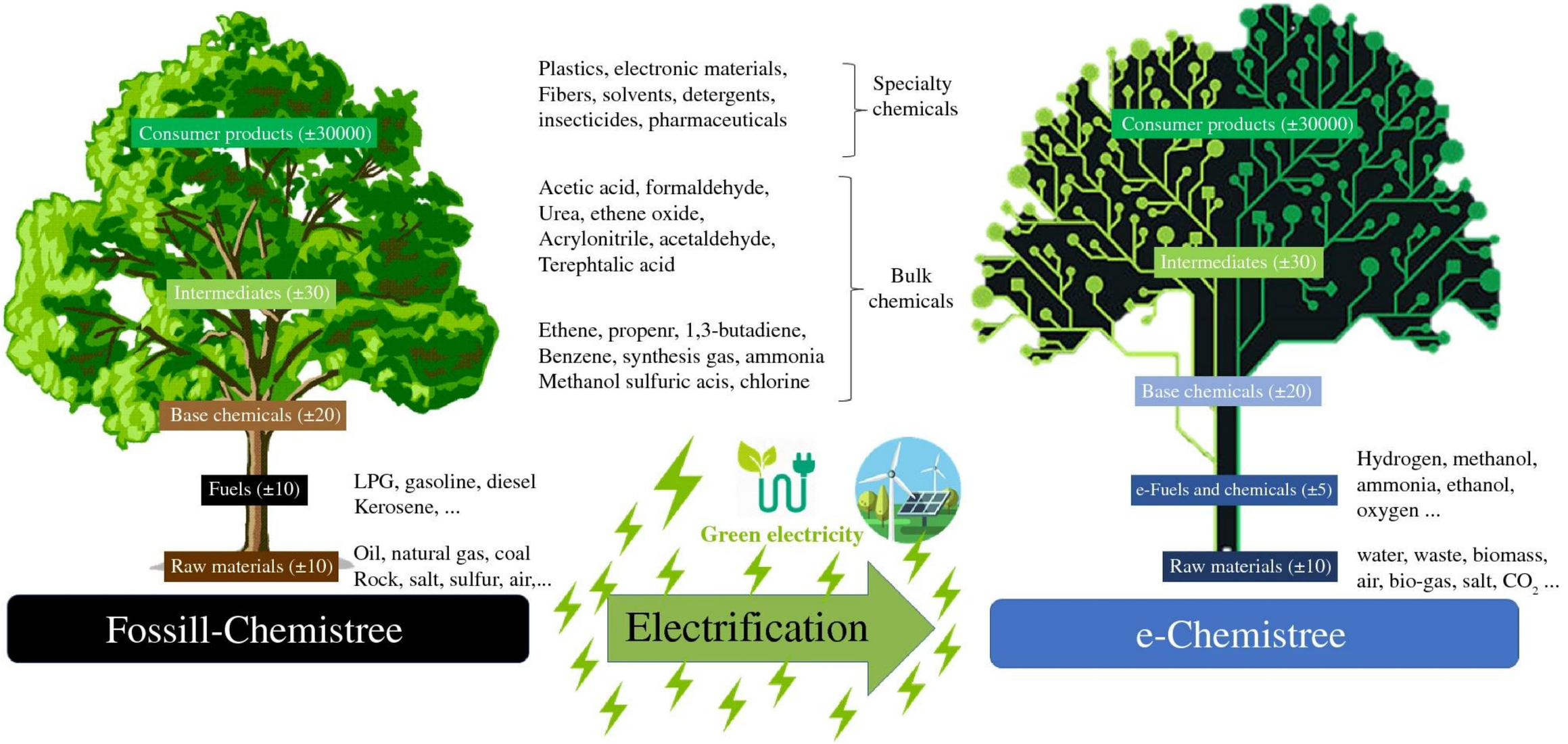
Source: CCC analysis.

CHALLENGES ENERGY & CHEMICAL INDUSTRY

Feedstock
Recarbonization

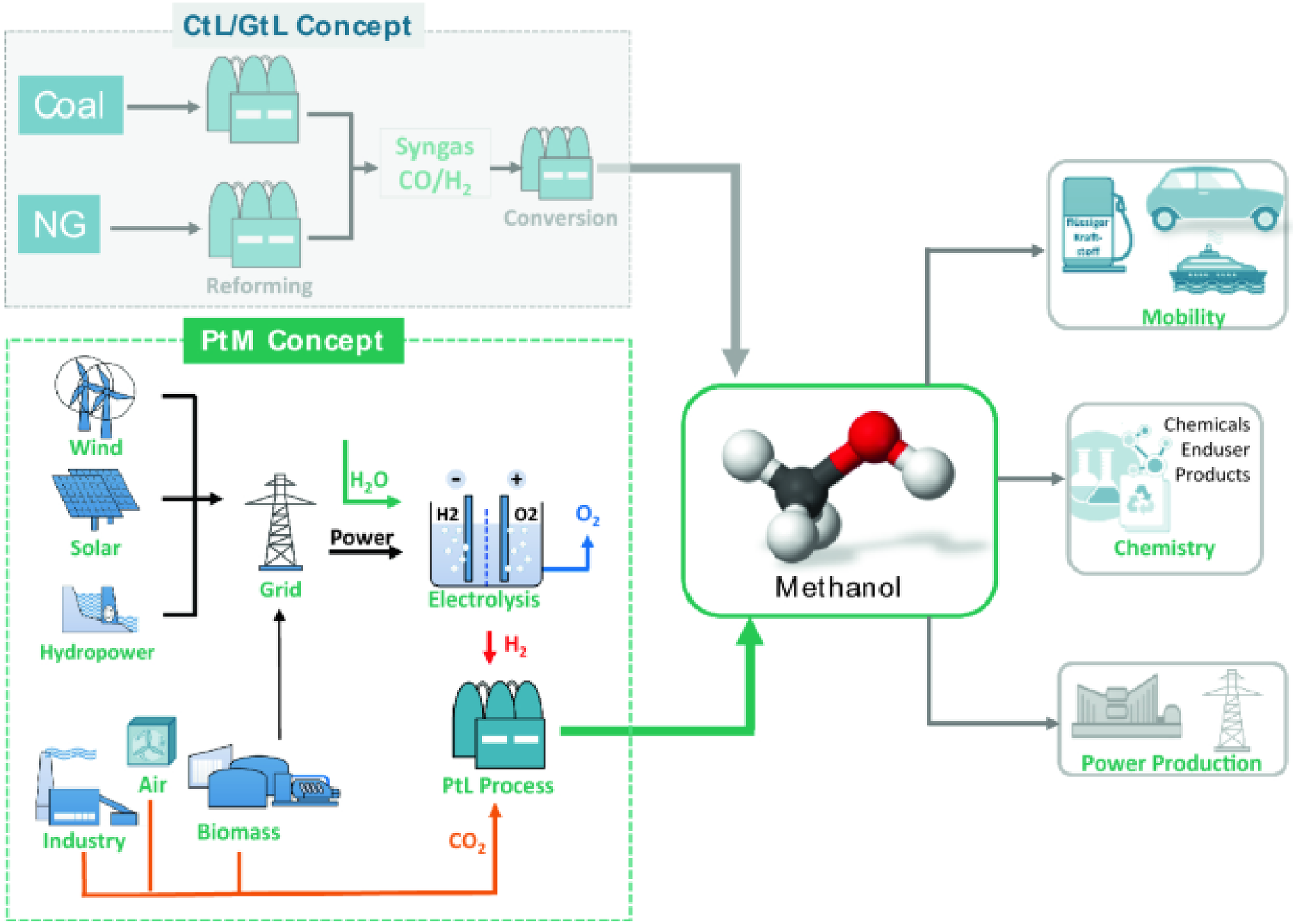
Energy
Decarbonization



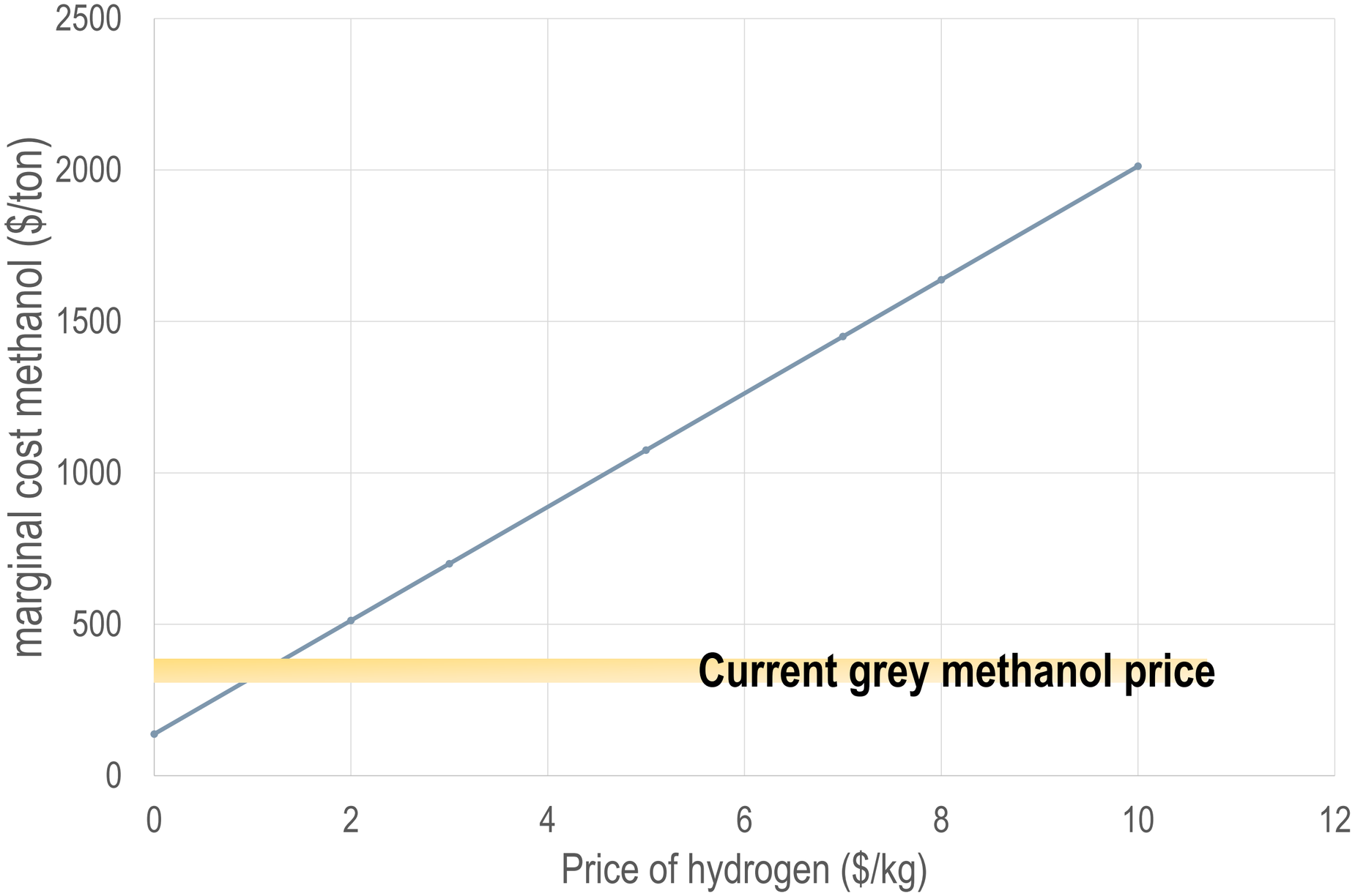


Electrification of the chemical industry is defined as the use of electricity to drive chemical processes including conversion, separation, and purification, and providing the necessary materials and utilities to assist in operating and controlling such processes

MRS Bulletin volume 46, 1187–1196 (2021)


CtL/GtL Concept
Coal
NG
Reforming
Syngas
CO/H2
Conversion
PtM Concept
Wind
Solar
Hydropower
Grid
H2O
Power
H2
O2
O2
Electrolysis
H2
PtL Process
Air
Industry
Biomass
CO2
Methanol
Mobility
Chemicals
Enduser
Products
Chemistry
Power Production

FROM AN ECONOMIC PERSPECTIVE: METHANOL AS AN EXAMPLE



BLUE CIRCLE
OLEFINS

Power2X Selects Honeywell Methanol-T Technology For eFuels Project In Rotter

Vioneo to use Honeywell UOP's methanol-to-olefins technology for Antwerp plant

1/13/2025 1:00:00 PM

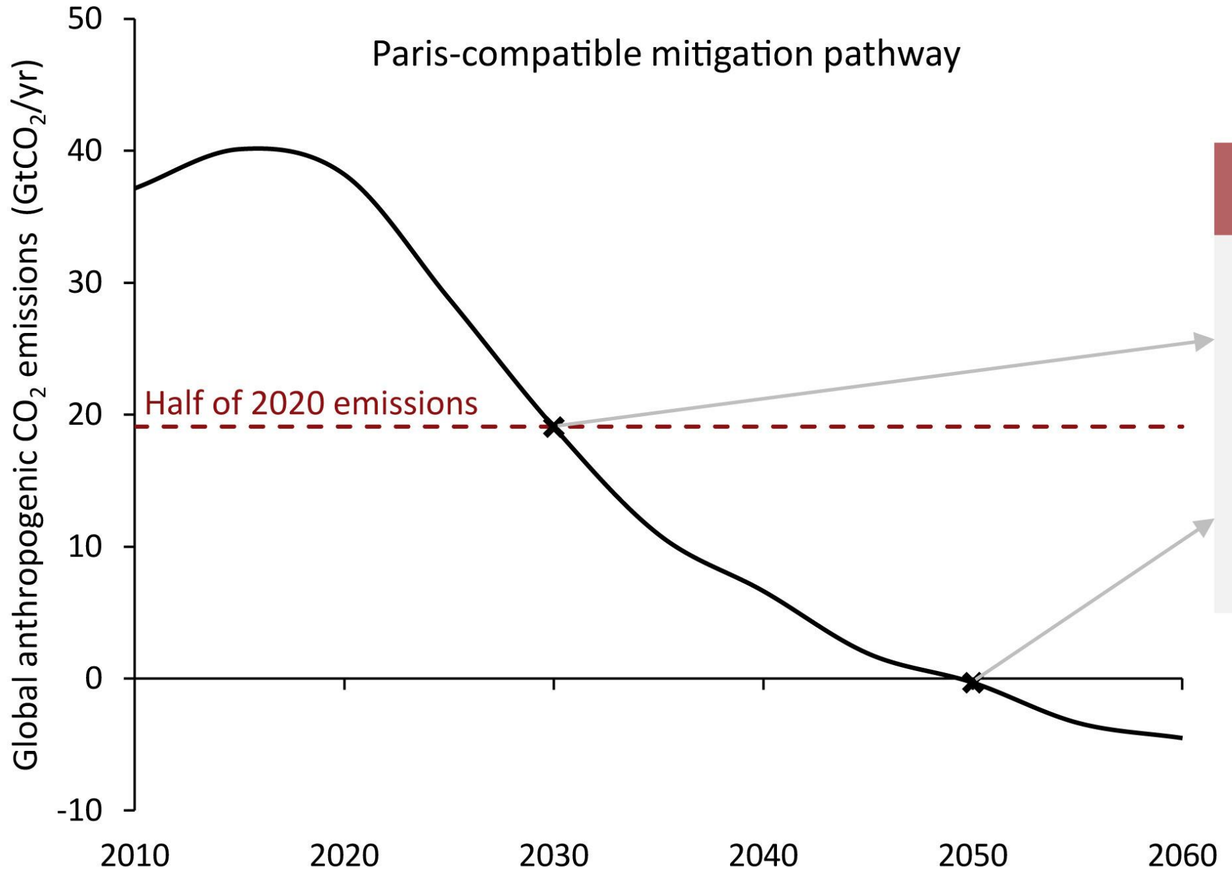
- Vioneo plans to produce plastics from green methanol at new European facility, to be powered by renewable energy
- Honeywell's advanced methanol-to-olefins technology selected for the production process

TU Delft

FROM A LIFE CYCLE PERSPECTIVE

PARIS COMPATIBILITY CRITERIA FOR CCU TECHNOLOGIES

Paris-compatible mitigation pathway



Paris compatibility criteria for CCU

	Technological maturity	Emission reduction
2030	$TRL \geq 6$	$\frac{E_{CCU}}{E_{subsitute}} \leq 50\%$
2050	$TRL \geq 1$	$E_{CCU} \leq 0$

Review

Limits to Paris compatibility of CO_2 capture and utilization

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https://doi.org/10.1016/j.oneear.2022.01.006

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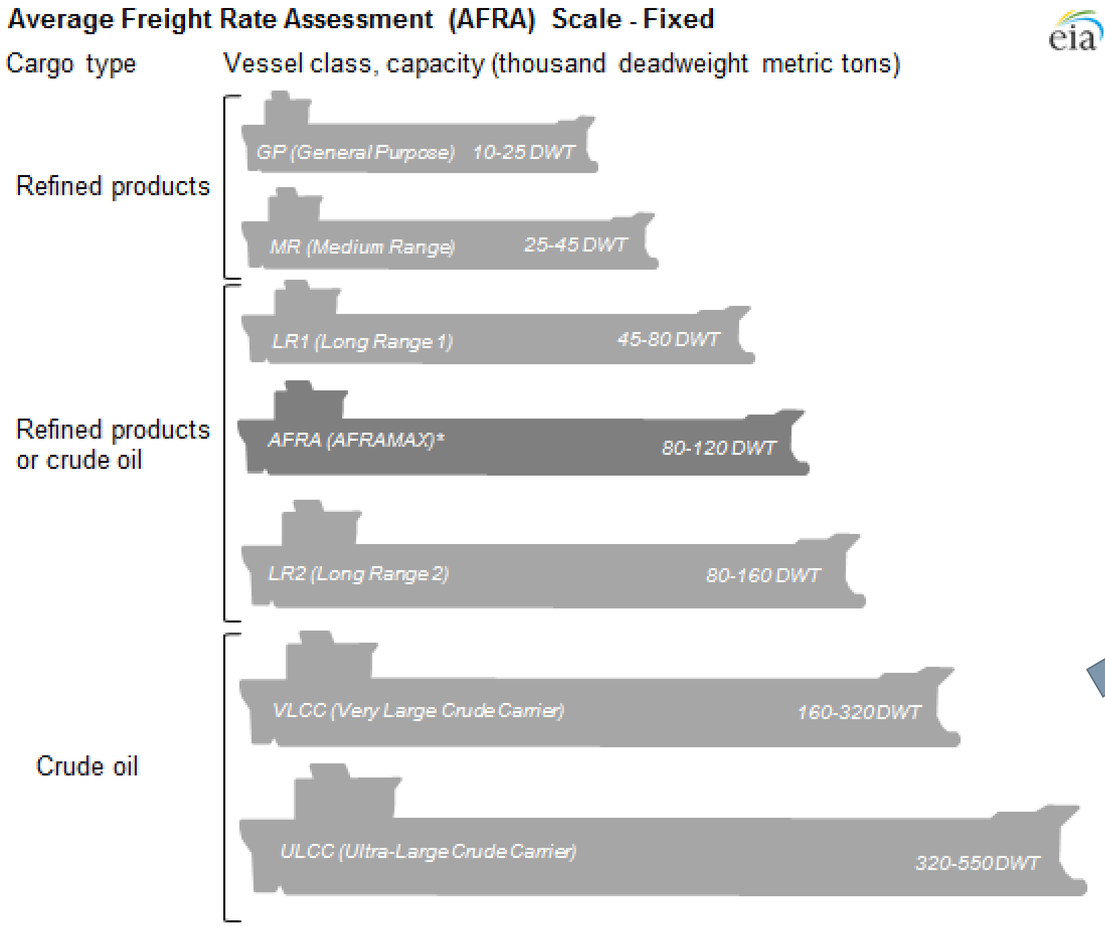
FROM A SUPPLY CHAIN PERSPECTIVE



Lets say 200 kton of oil is 8,5 EJ (10^{18} J)

Lets say off loading is 24 hr

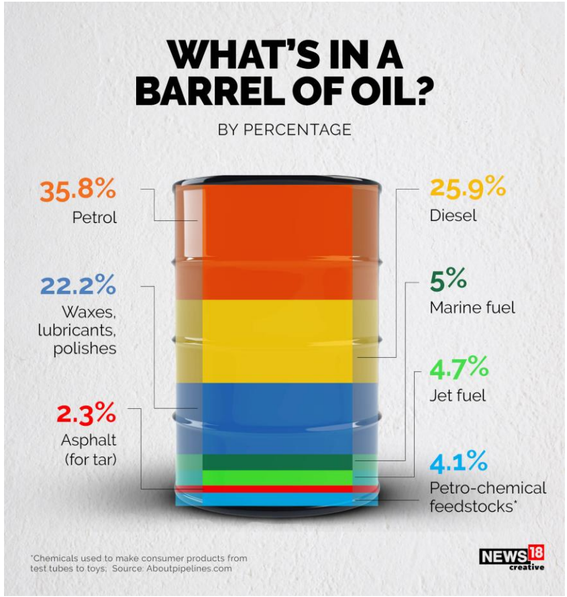
100 TW (during the 24 hrs) or 1,2 TWh

140 average off shore windmills northsea

Crude import rotterdam is currently around 100 Mton

Equivalent of 500 VLCC yearly

Equivalent to 700.000 windmills



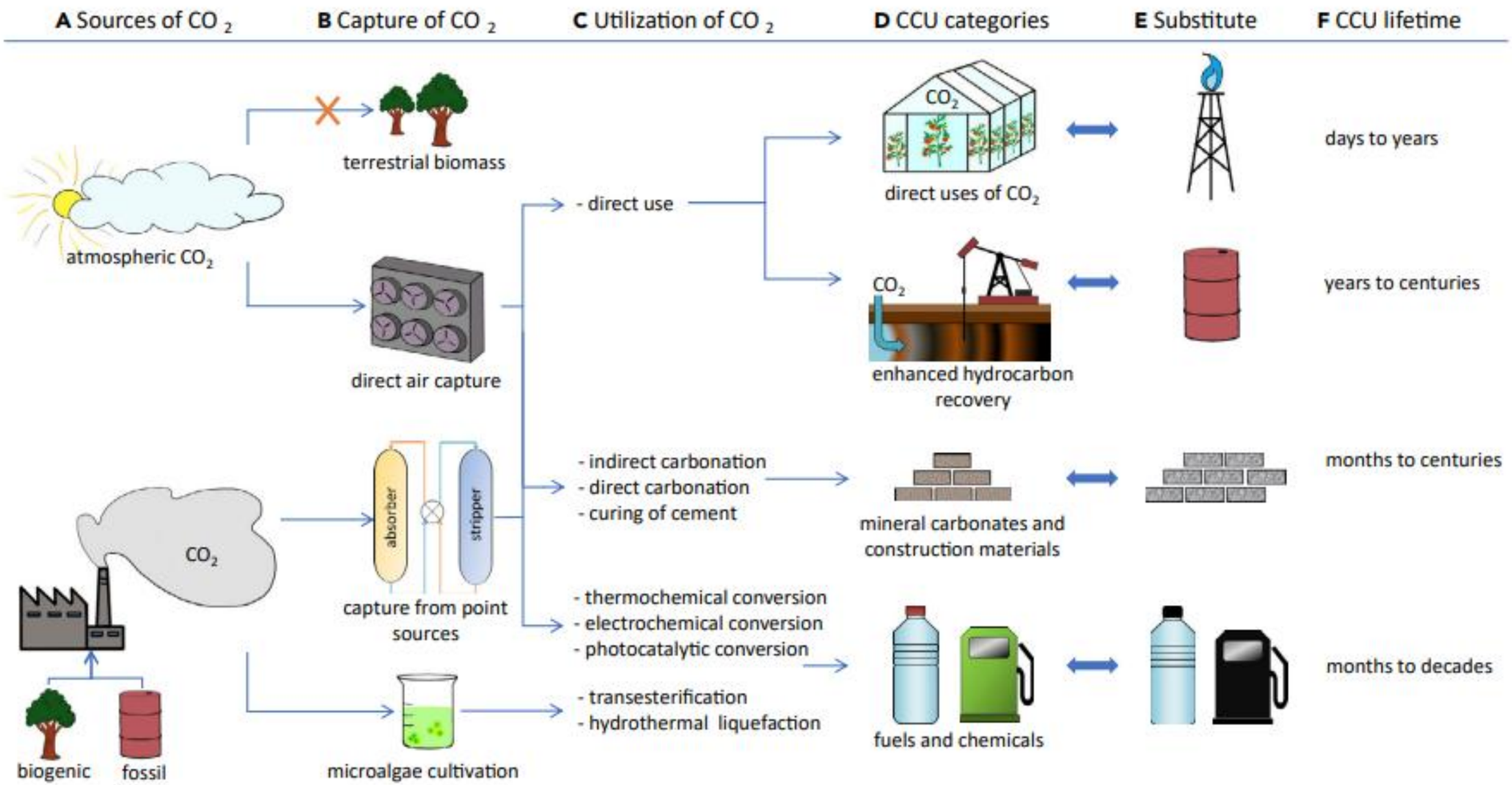
ELEPHANT IN THE ROOM

Where do we get the green CO2 from?

Just for kerosine (NL), this would be ~12 mton CO2

And

~70 TWh
(20 * Borssele nuclear power plant 480 MW)




To be inspired or not to be inspired
materials from thin air
Synthetic fuels
hydrogen
carbonmonoxide
ammonia
Fisher-Tropsch
Platform chemicals
alkanes
alcohols
ethers
carboxylic acids
Complex molecules
carbohydrates
lipids
proteins
nucleic acids

GREAT TO HAVE YOU ON BOARD OF THE CHANGE

Acknowledgements
Elena Perez Gallent
Anca Anastasapol
Iris Burgers
Hengameh Farahmandazad
Wiebren de Jong
Ruud Kortlever
…….

TUdelft&TNO

Let’s energise innovation together

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