The University Of Sheffield.

CO2 Chem
An EPSRC Grand Challenge Network

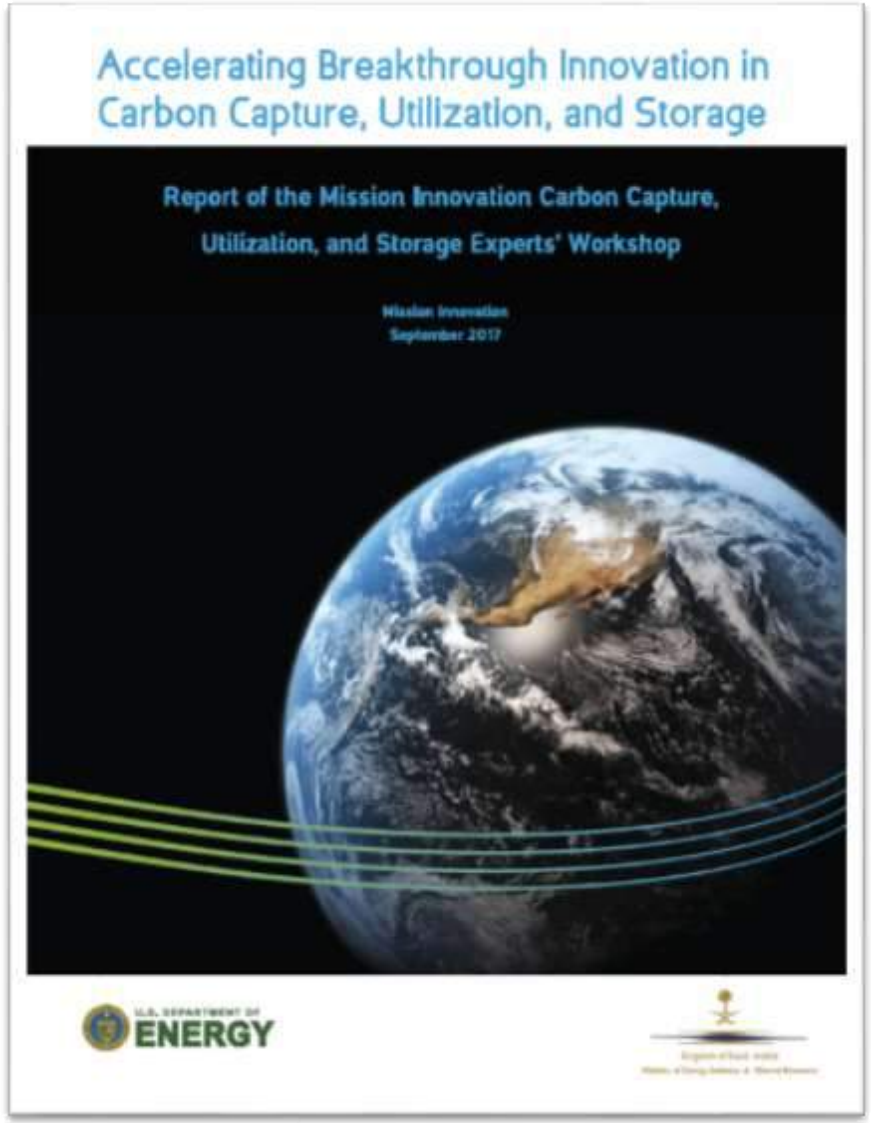
MISSION INNOVATION
Accelerating the Clean Energy Revolution

CO_2 UTILISATION IN A CIRCULAR ECONOMY

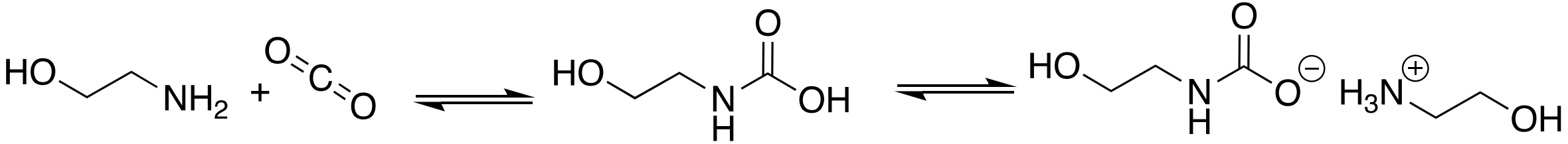
PROFESSOR PETER STYRING

DIRECTOR: CO2CHEM

THE UNIVERSITY OF SHEFFIELD



THERE IS A MYTH THAT "CO_2 IS UNREACTIVE"



CO_2 **IS** REACTIVE

THE CONCENTRATION IS LESS OF AN ISSUE IF THE **RATE CONSTANT** IS HIGH AND THE REACTION IS **FIRST ORDER** IN CO_2. ALTERNATIVELY, THE **FLOW RATE** COULD BE INCREASED.

BETTER TO USE HIGH REACTIVITY TO PRODUCE A PRODUCT

CCUS

"CCU SHOULD NOT BE CONSIDERED AS AN ALTERNATIVE TO CCS BUT AS A COMPONENT IN THE TOOLKIT AGAINST CARBON DIOXIDE REDUCTION (CDR)"

CARBON (DIOXIDE): MITIGATION AND AVOIDANCE

CAPTURE: REQUIRED FOR **S** BUT INTEGRAL TO **U** IS ITSELF CAPTURE

UTILISATION: CO_2 IS A COMMODITY NOT A WASTE

STORAGE: SEQUESTRATION OR AVOIDANCE?

The University Of Sheffield.

MISSION INNOVATION
Accelerating the Clean Energy Revolution

1. THERMOCHEMICAL CONVERSION & HYDROGENATION OF CO_2
2. ELECTROCHEMICAL & PHOTOCHEMICAL CONVERSION OF CO_2
3. CO_2 CONVERSION TO SOLID CARBONATES
4. BIOLOGICAL CO_2 UTILISATION

PRIORITY RESEARCH DIRECTIONS (PRDS)

CHEMICAL, BIOLOGICAL & HYBRID ROUTES

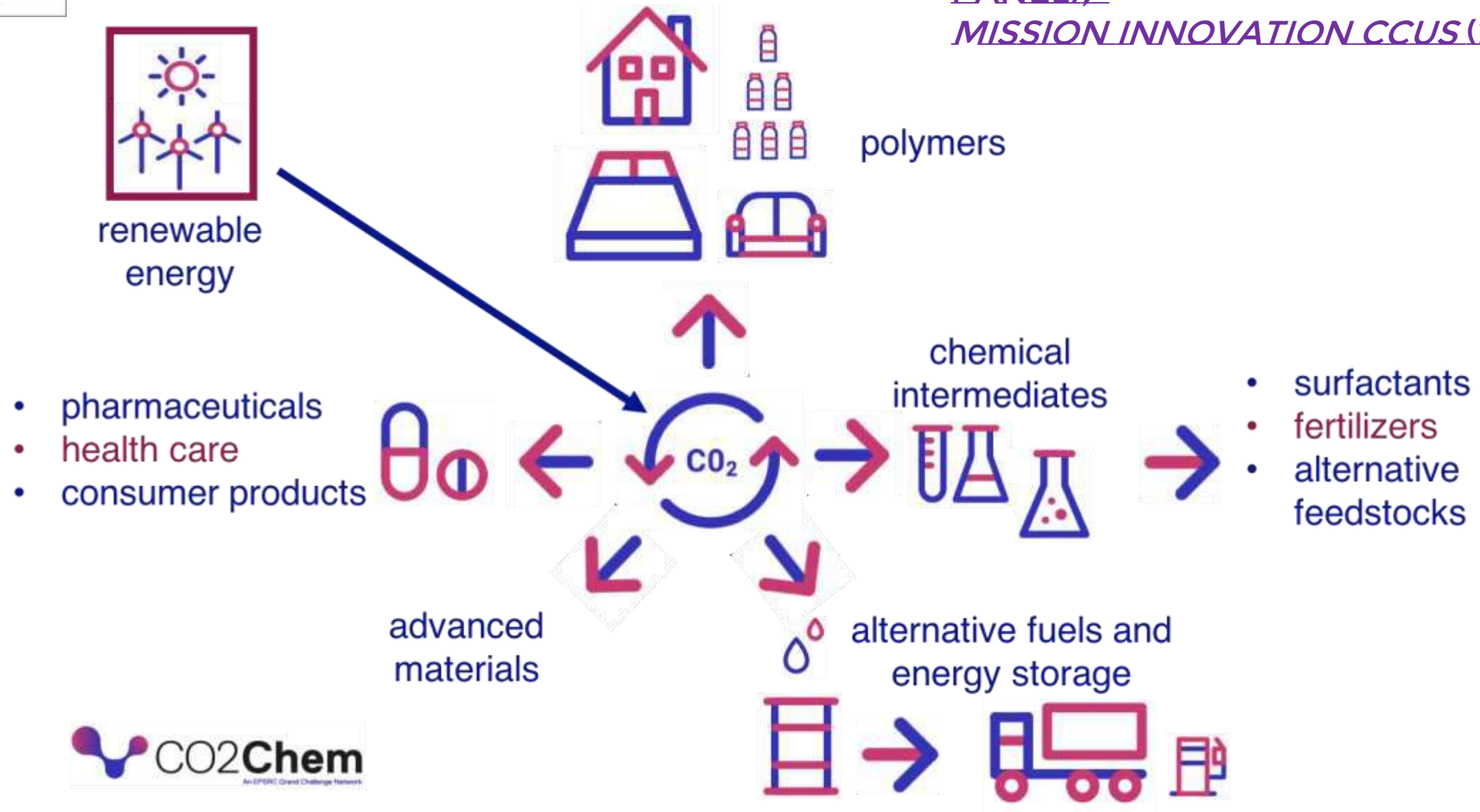
U-1 VALORISING CO_2 BY BREAKTHROUGH CATALYTIC TRANSFORMATIONS INTO FUELS AND CHEMICALS

U-2 CREATING NEW ROUTES TO CARBON-BASED FUNCTIONAL MATERIALS FROM CO_2

U-3 DESIGNING AND CONTROLLING MOLECULAR-SCALE INTERACTIONS FOR ELECTROCHEMICAL AND PHOTOCHEMICAL CONVERSION OF CO_2

The University Of Sheffield.

STYRING & BOUDREAU (& U1 PANEL),
MISSION INNOVATION CCUS (2017)



CO2Chem
An EPSRC Grand Challenge Network

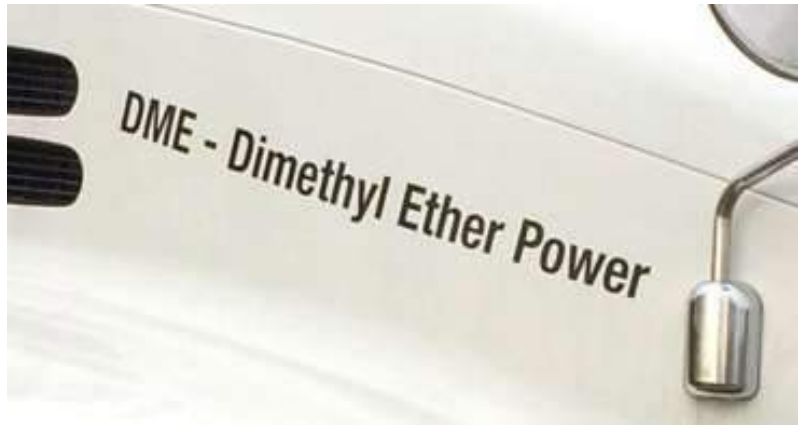
Priority Research Directions (PRDs)

Aviation Fuel (**not** synthetic kerosene)

Long Haul Road Freight Fuel (**not** synthetic diesel)

Maritime Fuels

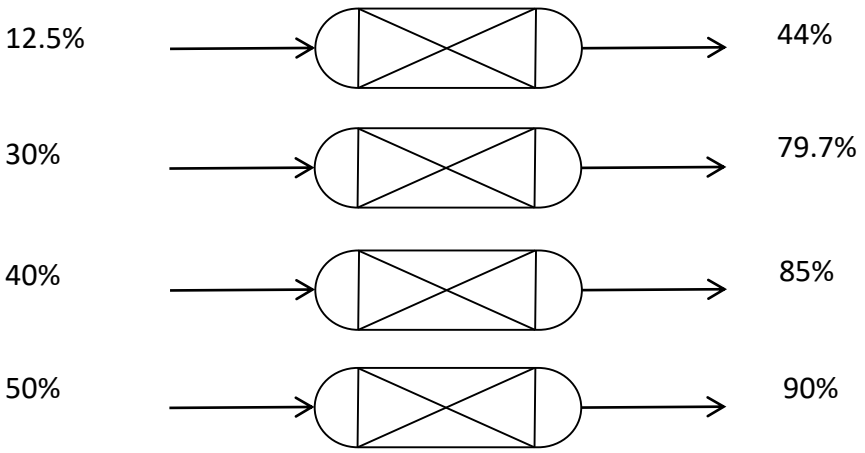
Construction Materials (aggregates and cement)



Diesel Engines are not the problem

Diesel **Fuels** are the problem

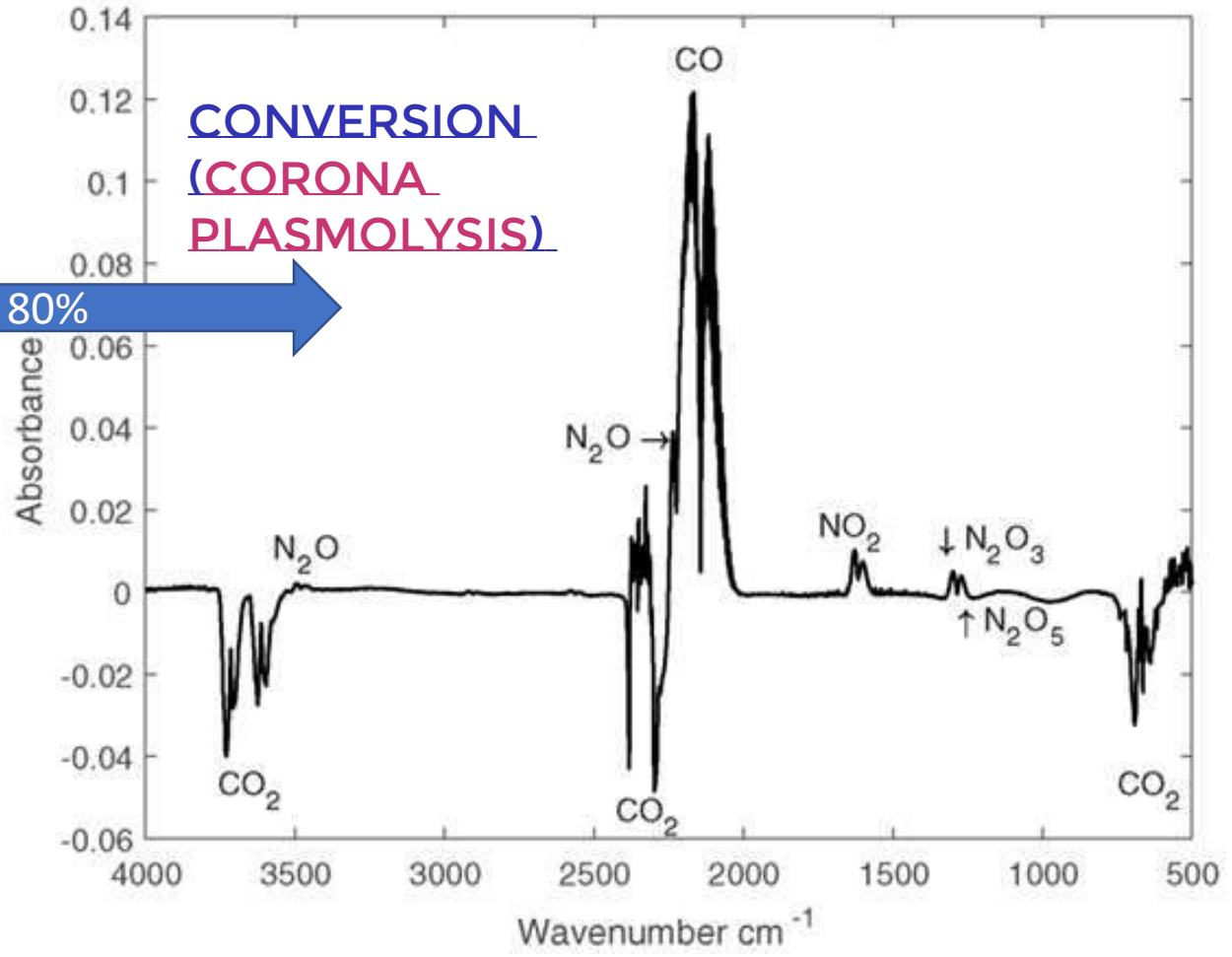
CC-CORONA PLASMOLYSIS (CCCP)



FLUREFIN (HIPSA)

80%

CONVERSION (CORONA PLASMOLYSIS)



MOSS, REED, ALLEN AND STYRING
FRONTIERS IN ENERGY RESEARCH (2017)

PURE CO_2 GIVES POOR CONVERSION

EU INNOVATION FUND, RED II & SCIENTIFIC ADVISORY MECHANISM (SAM)

Under SAM, CCU can enable a shift to RES and economic de-carbonisation

Environmentally safe CCU that contributes substantially to mitigating climate change (by **avoided** emissions, *c.f.* Lansink hierarchy)

Projects involving CCU shall deliver a net reduction in emissions and ensure **avoidance** or permanently stored CO_2

CO_2 stored or **avoided** on a sufficient scale

THERMO-, ELECTRO-, PHOTO-CHEMICAL

How do we best use weather dependent (‘renewable’) energy?

Chemical or Biological?

Chemists and Engineers create conditions far more efficient than nature can

The University Of Sheffield.

Should CCUS be

Industry Pull

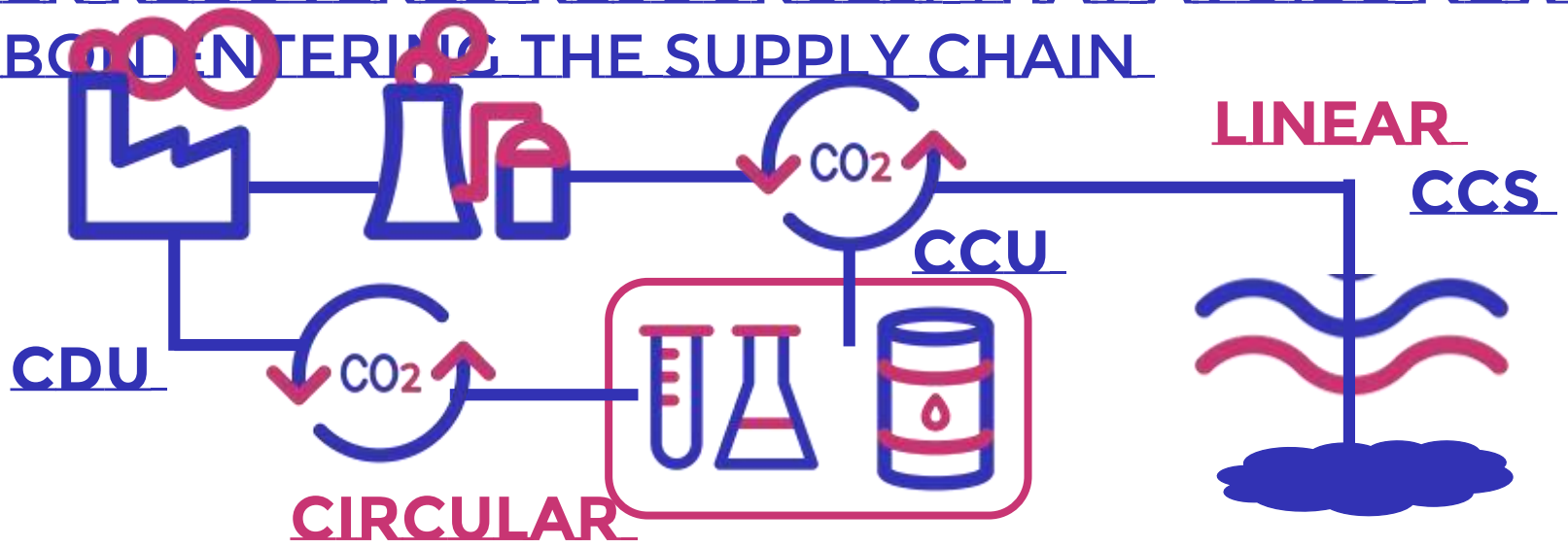
or

Policy Push?

SUMMARY

- IPCC (AMONGST OTHERS) HAS STATED THAT WE NEED TO STOP USING FOSSIL RESOURCES **AND** MITIGATE AGAINST CO_2 EMISSIONS

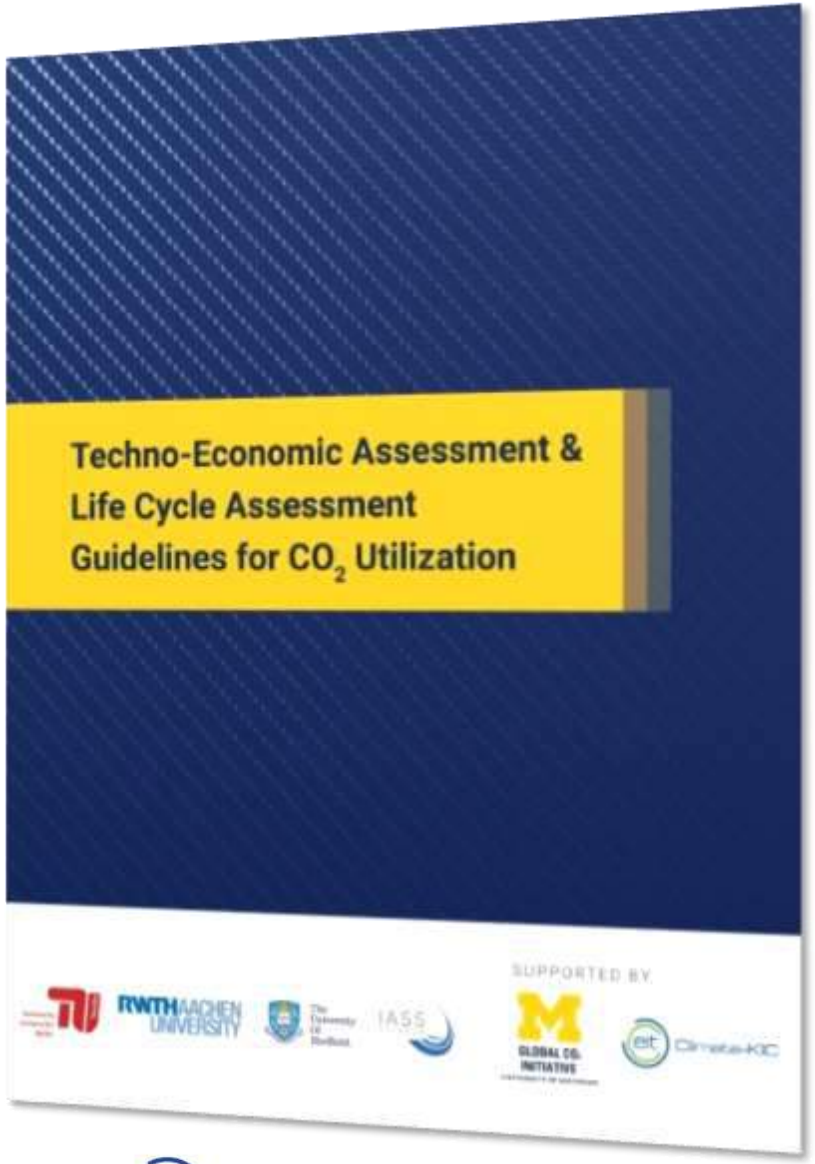
- CO_2 UTILISATION PROMOTES A CIRCULAR ECONOMY THAT USES CO_2 AS A NEW CARBON FEEDSTOCK (TOGETHER WITH OTHER RECOVERED RESOURCES) THAT AVOIDS NEW FOSSIL CARBON ENTERING THE SUPPLY CHAIN



LCA / TEA

Guidelines are available at:

http://umlib.us/CO2Guidelines

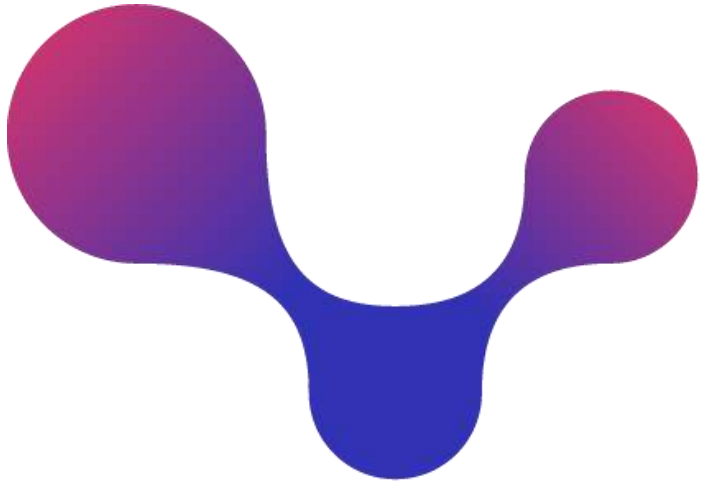


Supported by

SUMMARY

- CCS will give highest GHG mitigation but at high cost
- CCU will give economic benefit but mitigation is usually avoidance
- Combined CCUS will give the best combined benefits
- Models for the EU predict *ca.* 50% CCU and 50% CCS
- Highest potential for Utilisation is in eFuels (fossil carbon avoided)

The University Of Sheffield.



CO2 Chem

An EPSRC Grand Challenge Network

WWW.CO2CHEM.COM