

CCSA Technical Working Group Meeting

03/12/2024
10:00 (GMT)
11:00 (CET)



Agenda

	Time	Topic	Speaker
1.	10:00	Introduction & CCSA competition law policy notice	Andy Brown, Co-chair
2.	10:10	CCSA TWG Task Subgroup Updates	CCSA Secretariat
3.	10:40	CCSA Update: open, recently submitted & upcoming consultations	CCSA Secretariat
4.	10:45	External Presentation: Recent advances in the commercialization of mineralization/carbonation in the CCU space.	Paula Carey, Carbon8
5.	11:10	Presentation: Overview of SAF technologies and pilot projects in the UK	David Blythe & Amy Ruddock, Willis Lease
6.	11:35	Presentation: Opportunity for CCS in UK EfW	Amelia Mitchell, ERM
7.	11:55	Conclusions and AOB	Andy Brown, Co-chair



House keeping & Introductions

- Slides & Recording will be available for members after the meeting
- CCSA Competition Law Policy notice is attached to the meeting invite and available on the CCSA website
- If you are not speaking, please mute your microphone
- Please **raise your hand** if you wish to comment, you will be invited to come off of mute, if you can also turn on your camera
- Please also pose any **comments in the chat** and these will be picked up by the secretariat
- **Introductions** of any new members joining the call
- Approval of September minutes

CCSA TWG Task Subgroup Updates

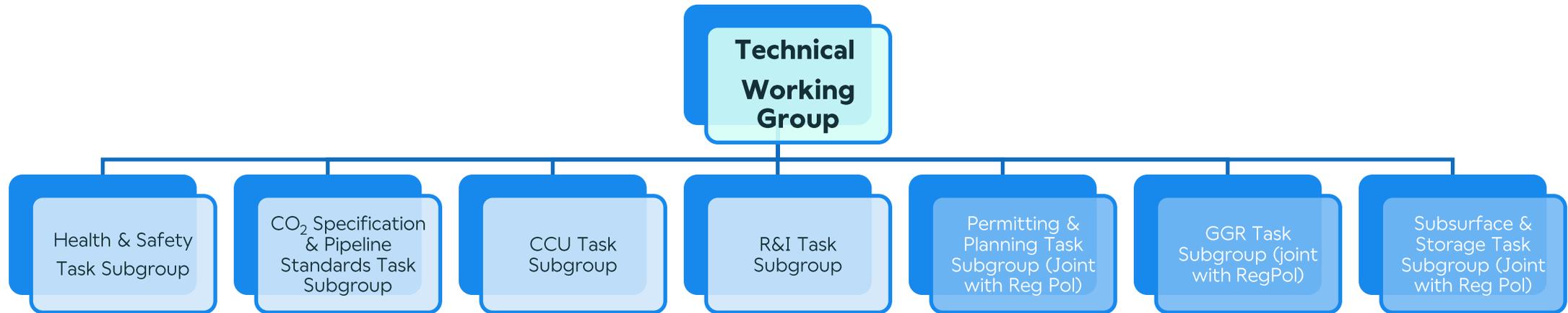
CCSA Secretariat



CCSA TWG Task Subgroup Activity

CCSA Lead: Despoina Tsimprikidou

Co-Chairs: Andy Brown (Progressive Energy), Suzanne Ferguson (Wood), Alastair Rennie (Yo Energy)



→ If you would like to be involved in these Task Subgroups please reach out to the CCSA Secretariat.



Permitting & Planning Task Subgroup *Joint with the Regulation & Policy Working Group*



Group Convenors: Matt Brown (RWE), Nicola Smith (SSE), Aleks Dragicevic (Viridor)

Focus: Provide clarity on the planning regimes for different projects; Establish coordinated tendering and permits procedure; Expedite permitting process; Provide clarity on the EU planning regime.

Current priorities:

- CCSA Capture Rate Efficiency Position Paper published [here](#).
- EALs: 6 Draft EALs proposed/shared with members → consultation overdue, 7 EAL dossiers to be consulted on in total.
- Solvent Disclosure
- ELVs

Previous Meeting: 8th July 2024 - EA/CCSA permitting teach-in session – 8th July (materials available [here](#))

Recent & Upcoming activity:

- Continuous engagement between industry & Environment Agency & regulators on key topics.
- Environmental Capacity in Industrial Clusters Phase 3 report published [here](#).

Next Meeting: early 2025

GGR Task Subgroup

Joint with the Regulation & Policy Working Group



Group Convenors: Greg Williams (Evero Energy)

CCSA lead: Despoina Tsimpridou

Previous meeting: 2nd December 2024

- Purpose: COP29 & Article 6 Updates, VCM Updates, GGR Industry Group Discussion Recap

Next steps:

- Feeding back to DESNZ on GGR Business Model Design.
 - Price Discovery Incentive
 - Fair Market Value Principles
 - Offtaker Risk
- Awaiting Government response on the Integrating GGRs in the UK ETS consultation.
- Feeding into DESNZ consultation on creating high integrity VCMs (early 2025).
- Aligning messaging on the inclusion of NPT in the UK ETS consultation.

Next meeting: end of January/beginning of February 2025

Health & Safety Task Subgroup



Convenors: Toby St Ledger (Harbour Energy), Sebastien Cochet (DNV), Jenny Sutcliffe (Phillips66)

CCSA lead: Despoina Tsimprikidou

Previous meeting: 8th October 2024

- Purpose: health & safety priority setting
 - Offshore and nearshore SSIVs
 - ESDV leakage rates
 - Emergency Responses
 - CO2 Hazard & Effects Criteria
 - Supply Chain & 3rd party assets
 - Venting (following Skylark Project)

Next steps for the subgroup

- Establish an internal CCSA library to collate useful health & safety resources & industry standards.
- Exploratory, operator-focused, meetings to be planned throughout January & February 2025 to collate key points of discussion & outcomes (if any).
- Engaging with the HSE to enable knowledge exchange and enhance collaborative ways of working.

Research & Innovation Task Subgroup



Convenors: n/a

CCSA lead: Rebecca Bell

Previous meeting: 7th November 2024

- Purpose: Workshop with KPMG on Cost Reduction
- Knowledge exchange (and how to do it effectively) was a key topic

Next meeting: TBC

Next steps:

- KPMG writing up Cost Reduction Report
- Contact Rebecca Bell / KPMG if you have any case studies or further input



CCU Task Subgroup



Convenors: n/a

CCSA lead: Despoina Tsimprikidou (UK) & Sophie Deijkers (EU)

Previous meeting: 15th March 2024

Current Priority: Review and update the CCSA's CCU position paper

Next meeting: 18th December 2024

- Purpose: finalise member comments on the position paper and discuss approach for DESNZ engagement.

Next steps:

- Publish CCU Position Paper & circulate to DESNZ in early January 2025.
- Determine EU CCU position during 2025.



EU Policy Task Subgroup *Joint with the Regulation & Policy Working Group*

Position paper on low-carbon hydrogen (EU focus)

Key recommendations framed under Clean Industrial Deal

In contact w DG ENER C.2 to set up meeting 1st half January

Webinar/focus session with members and EC later in Q1

Next steps:

- Second draft to members for comments 3 - 6/12 COB
- Final version for info to members w/c 9/12
- Publication w/c 16/12



Subsurface and Storage Task Subgroup

Joint with the Regulation & Policy Working Group



Group Convenors: Mark Weldon and John Ford (Petrostrat)

CCSA Lead: Beth Hebditch

Previous group-wide meeting: 10th September 2024 on the new CCS directive Guidance Documents

Storage Developer Task & Finish Group: developing industry-wide response to the SEAA

- The CCSA, on behalf of storage developers and supported by the subsurface taskforce (STF), submitted a position on The Crown Estate's (TCE's) Storage Exploration and Appraisal Agreement (SEAA)

Next subgroup meeting: December or early January

- STF paper discussion: importance of storage project appraisal activities and carbon budget objectives

Next steps and key priorities for the subgroup

- ✓ Continue to align industry, including external taskforces, with TCE
- ✓ Supporting the BGS project to develop a UK-focussed review of containment risks for CO₂ storage to inform the insurance industry



Industry response to The Crown Estate's proposal for a Storage Exploration and Appraisal Agreement (SEAA)
30th October 2024

The CCSA brings together a wide range of specialist companies across the spectrum of Carbon Capture, Utilisation and Storage (CCUS) technology, as well as a variety of support services to the energy sector. The CCSA exists to represent the interests of its members in accelerating the commercial deployment of CCUS in the UK, EU and internationally through advocacy and collaboration to achieve net zero emissions by 2050.

The CCSA submits this industry-wide position on behalf of storage developers, with support from the Subsurface Taskforce (STF).



The Importance of Storage Project Appraisal Activities and Carbon Budget Objectives

Subsurface Task Force

November 2024

Promoting responsible use of UK subsurface storage and energy resources



CO2 Specification & Pipeline Standards Task Subgroup



Convenors: Andy Brown (Progressive), Tiana Walker (Storegga), Ben Rowton (NPL)

CCSA lead: Beth Hebditch (UK) & Charles-Albert Bareth (EU)

Previous meeting: 22nd February 2024

- Purpose: covering updates across impurities, Northern Lights Project, acoustic monitoring for marine facilities and Forecasting North Sea Infrastructure

Next meeting: TBC

Next steps and key priorities for the subgroup

- Next steps and alignment of standardisation in the UK and across Europe
- The CCSA joined CEN TC/474 as a liaison member
- *Further updates in slides to follow*

CEN TC/474

October Plenary meeting in Copenhagen

- Aim to agree European CCUS standards in next years
- Highly important topic, applies to the UK
- UK represented via BSI
- Chairman: Adriaan den Herder, Gasunie

Workstreams

- WG1 on CO2 specification and quality (convenor Jens Erfurth, OGE)
- WG2 on pipeline transport (convenor Matthijs van den Hatert, Gasunie)
- WG3 CO2 quantification and verification (convenor Gabriele Chinello, TÜV-SÜD National Engineering Laboratory)
- WG4 Storage (Christine Ringstad, SINTEF)
- WG5 Non-Pipeline Transport

Next plenary in Amsterdam, 27-28 March

**Members are invited to
contribute to CEN TC 474**



Any questions?



Consultations

Code	Recently completed consultations (x7)	Date
MHCLG	Proposed reforms to the National Planning Policy Framework	24 Sept
Regulators Committee	Skills Inquiry	27 Sept
Ofgem	Regional Energy Strategic Plan Policy Framework	8 Oct
Gold Standard	Engineered CDR Activity Requirements	4 Oct
DBT	UK Industrial Strategy	24 Nov
PAC	CCUS PAC Inquiry	28 Nov
NESO	Connections Reform	2 Dec

Code	Open consultations (x6)	Date
DESNZ	Capacity Market	10 Dec
DESNZ	Capacity Market – proposals to maintain security of supply and enable flexible capacity to decarbonise	10 Dec
Ministry of Justice	Judicial Review and Nationally Significant Infrastructure Projects	30 Dec
ESNZ Committee	Workforce Planning to deliver clean, secure energy	13 Jan
DfT	Renewable Transport Fuel Obligation Statutory Review & future of scheme	27 Jan
ETS Authority	Inclusion of NPT in the UK ETS	23 Jan
Welsh Government	Preferred Policy on CCUS	24 Feb

Code	Expected Consultations – overdue or expected in early 2024 (x7)	Date
BEIS / HMT	UK Green Taxonomy	Q3-23 (overdue)
EA	EALs for CCS	Q3-23 (overdue)
HMT	Secondary legislation on ETS cap	By 2024
HMT	Market interventions to mobilise additional finance through voluntary markets	2023 (overdue)
HMT / DESNZ	Steps for high integrity VCM market	Q1-2025 (postponed)
DESNZ	Biomass Sustainability Criteria	2024
NESO	Strategic Spatial Energy Plan Methodology	2024
HSE	Requirements for HSE regulation development to facilitate CCUS and Hydrogen deployment	2024



External Presentation:

Recent advances in the commercialization of mineralization/carbonation in the CCU space

Paula Carey, Carbon8



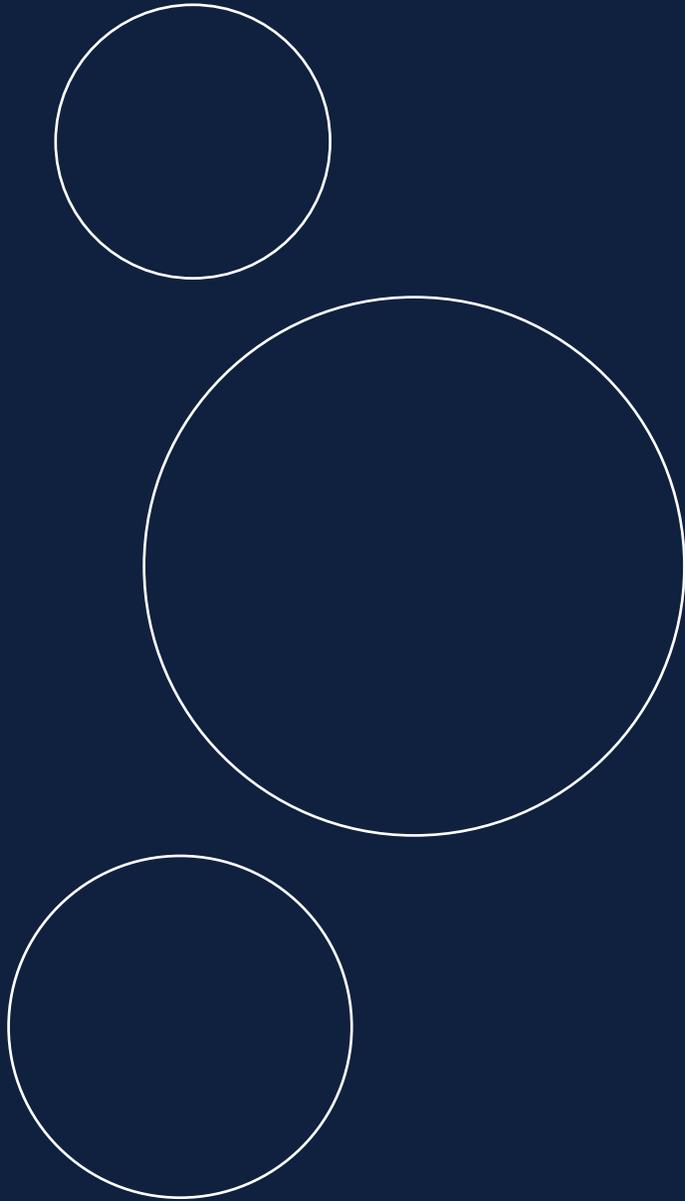


carbon8

3rd December 2024 CCSA

Recent advances in the commercialisation of
mineralisation/carbonation in the CCU space

Dr Paula Carey
Founder & CTO, Carbon8

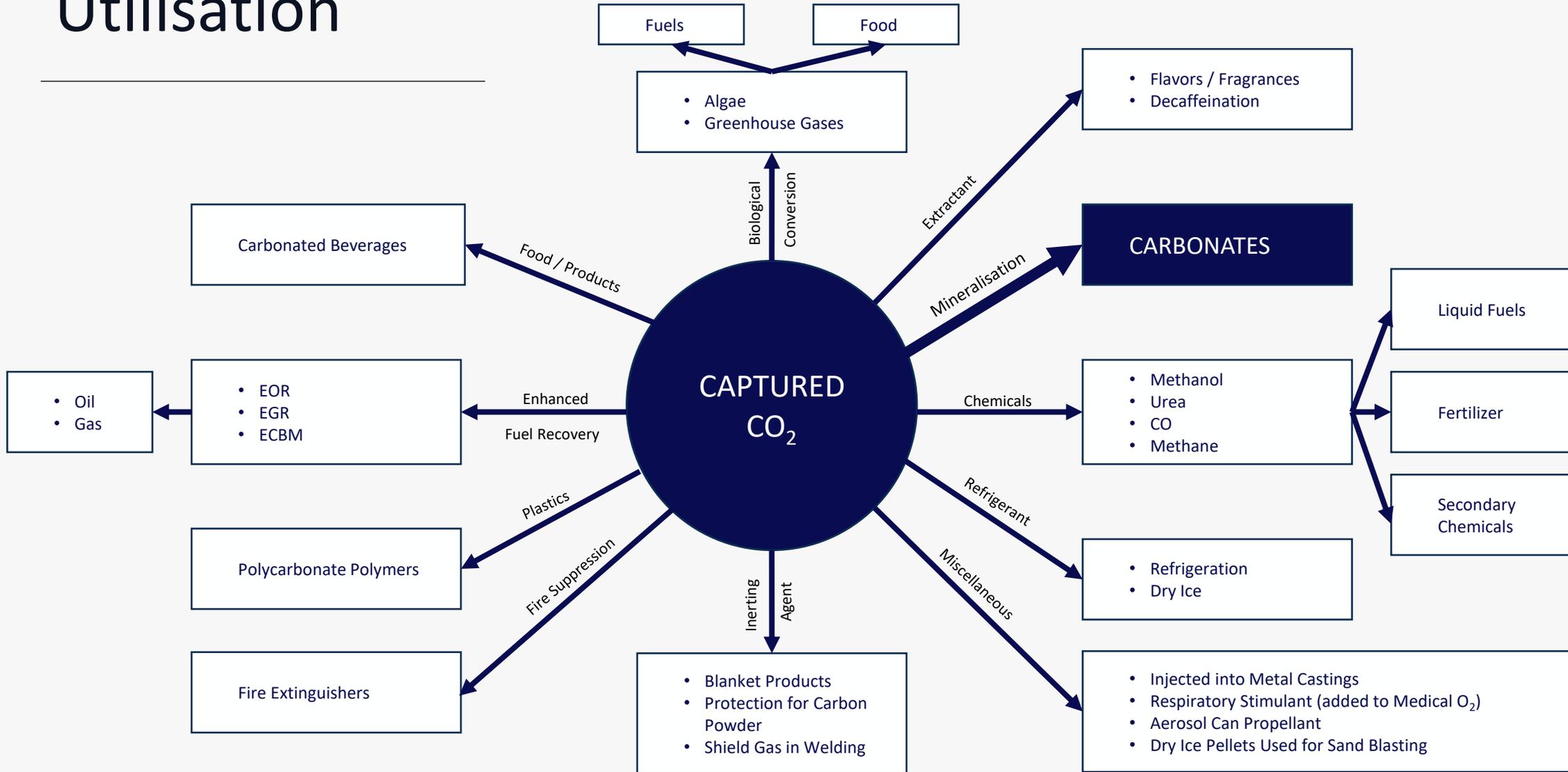


Content

- What is carbonation/mineralization
- What are the benefits of carbonation
- What is the potential scale of CO₂ capture
- Who are the principal actors in the carbonation of solids to products

Carbon Capture and Utilisation

Carbon Utilisation Solutions



What is Carbonation and Mineralisation?

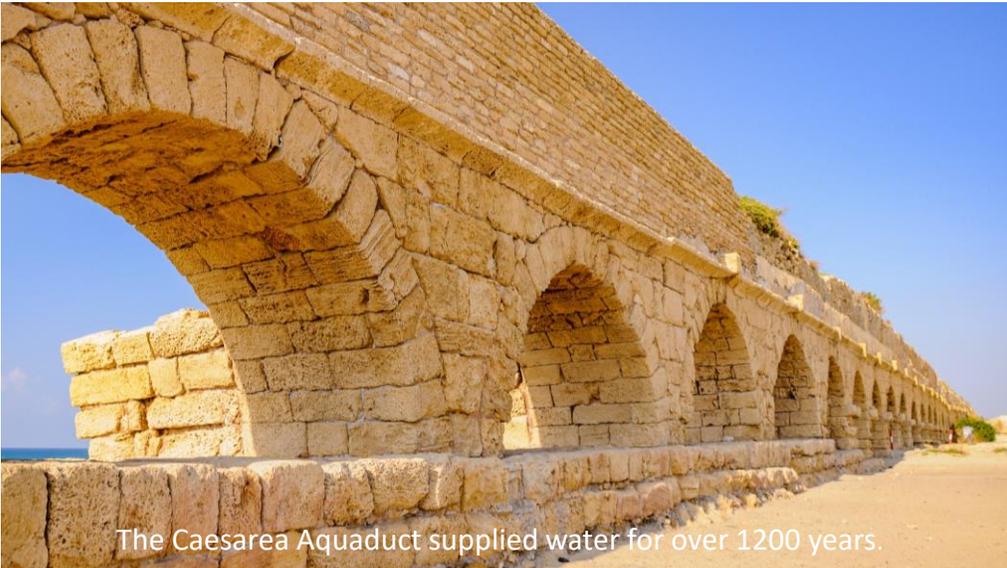
A natural process

- Requires only water to ionise the CO_2
- Exothermic
- Carbonates are very stable – permanent capture of CO_2

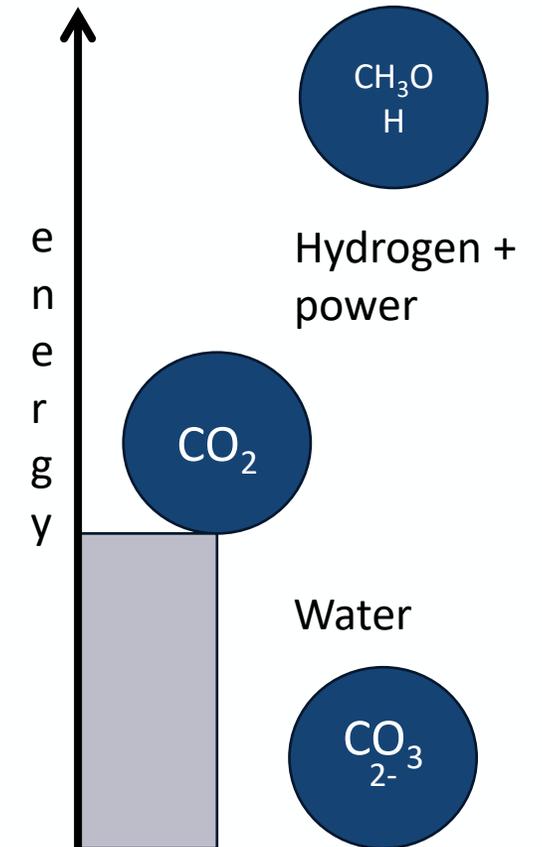
Basic and Ultrabasic rocks weather

Lime mortars gain strength

Concrete carbonates – consider deleterious when has steel reinforcements



The Caesarea Aquaduct supplied water for over 1200 years.



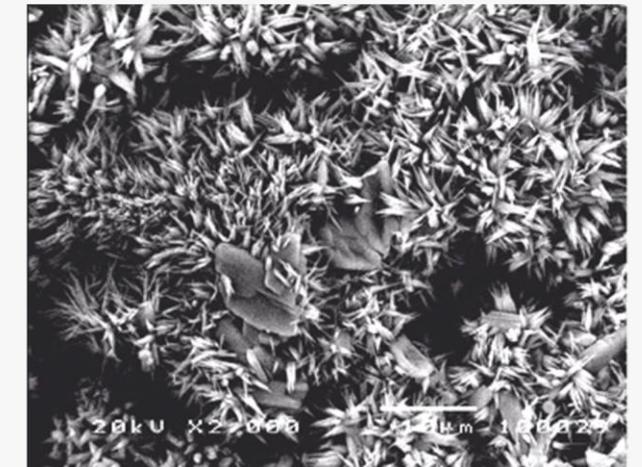
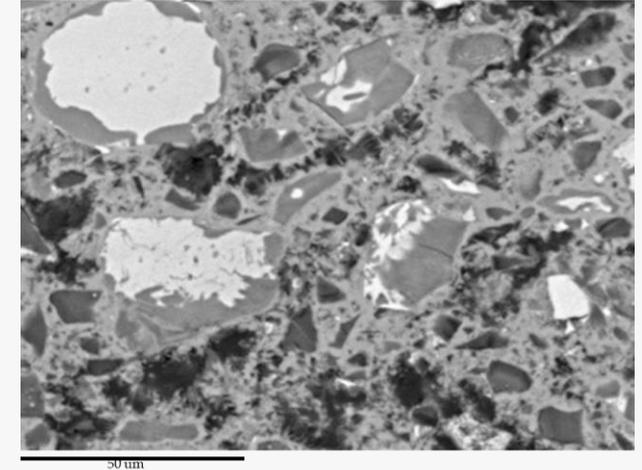
What is Carbonation and Mineralisation?

Permanent CCU

- Reaction of calcium, magnesium (and iron) oxides, hydroxides and silicates with CO₂ to form carbonates



- Ca, Mg compounds can be found in:
 - basic and ultrabasic rocks - basalt, dunite (olivine) and serpentinite (mine tailings)
 - alkaline industrial residues – steel slags, APCr, cement residues or crushed concrete
- Two principal environments for carbonation
 - **WET** – High water solid ratios - precipitation of carbonates from solution
 - **DRY** – Water solid ratios of < 1
 - Need water to allow the CO₂ to ionise in order to react with the solid
 - Reaction can be controlled at atmospheric temperatures and pressures



Advantages of Carbonation

- Permanent capture of CO₂
- Exothermic process – CaCO₃ formation releases energy
- Can use CO₂ from flue gas directly without need for purification
- Or can use CO₂ from DAC reducing the need for final purification
- Most frequently discussed routes for mineralisation are:
 - In-situ
 - Enhanced weathering and
 - Ex-situ



Permanent CCU

- Large quantities of reactive material, both natural and anthropogenic
- With ex-situ carbonation, can manufacture products with value
 - principally in construction (35-40% of anthropogenic emissions)

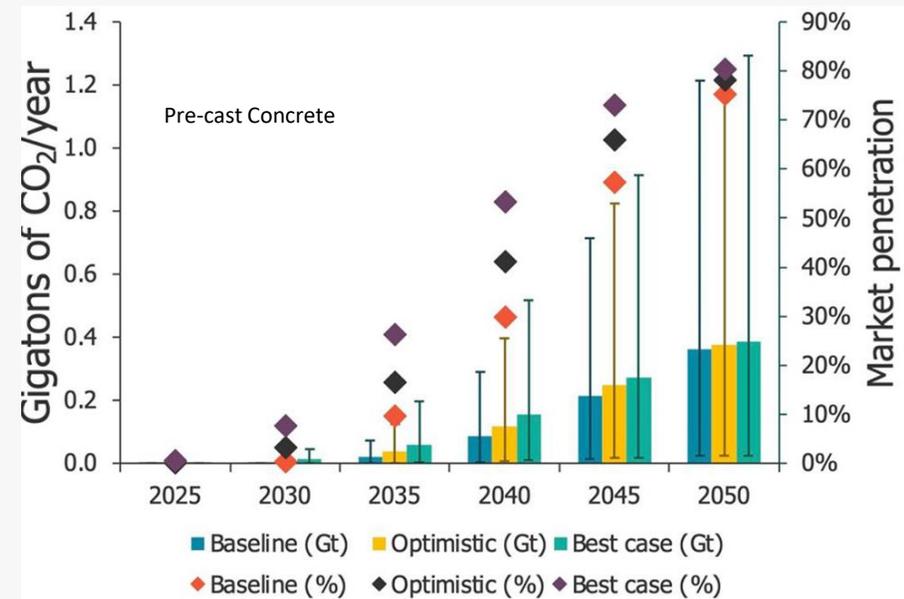
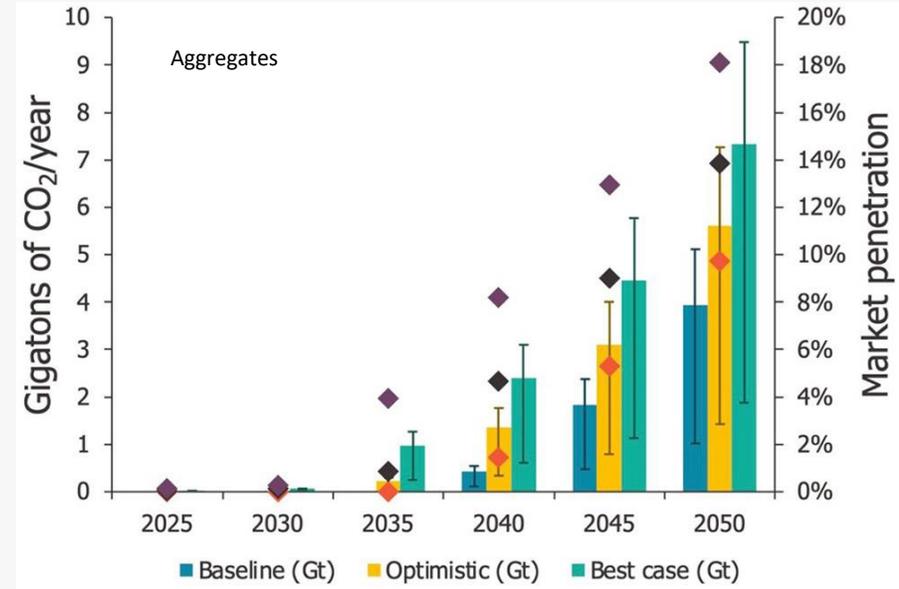
Snap-shot of active players with carbonated products

Carbonation Companies

Process	Locations	Technology	TRL	Reaction Environment	Product	Production Status (production)	CO ₂ Used
Blue Planet	California, USA	CO ₂ sequestered coating over a substrate	8	Flue gas CO ₂ and recycled concrete -wet carbonation	Lightweight aggregate	Pilot/demonstration (quantities unknown)	Not known
Carbcrete	Canada	Carbonation of steel slag	7	Raised temperature and pressure	Cement-free concrete	Pilot	200 kg/day
Carboncure	Canada, USA	Direct injection of CO ₂ gas into green concrete/mortar	9	Ambient temperature and pressure	Accelerated cured concrete	Used in >40 pre-cast plants in USA/ Canada	3% CO ₂ avoided
Carbon8 Systems	UK	Accelerated Carbonation Technology	9	Ambient temperature and pressure	Aggregates and fill e.g. for blocks, and screed	Technology Licences	100-200kg/t aggregate
CCm Research	UK	CO ₂ combined ammonia-coated waste fibres	8	Waste fibres and CO ₂ from exhaust gas	Fertilizer	Demonstration/fully commercial	85% GHG reduction
Carboclave	Ontario, Canada	Precipitation of nano-CaCO ₃ crystals	8	CO ₂ curing of concrete	Concrete blocks	Quantities unknown	300g CO ₂ per 20cm block
C2CA Technology	Netherlands	Carbonation of fines from recycled concrete	6	unknown	SCM and clean natural aggregates	Demonstration, funding for first plant	Plan for 30,000 t CO ₂ /yr saving
Concrete4Change	UK	CO ₂ carrier (waste materials) added to concrete	6	unknown	Additive for concrete	Five pilot studies	20% reduction in CO ₂ footprint of concrete
Neustark	Switzerland	Carbonation of recycled concrete	9	unknown	Improved recycled concrete aggregate	22 commercial plants in Europe	2962 t/CO ₂ removed
Orbix	Belgium	Carbonation of steel slag using CO ₂ from flue gas	9	Autoclave-based (100% CO ₂ , 0.5-10 MPa and 20 -140°C)	Construction materials including blocks and tiles	100,000 t	200kg/t
Paebbl	Netherlands	CO ₂ from flue gas captured in ground olivine	6	High pressure	SCM, filler for other products e.g. paper	Pilot/demonstration	300 kg CO ₂ per tonne product

Scale of Carbonation

POTENTIAL (Gt CO ₂ equivalent)	SOURCE
3.6 (aggregates) (2030)	Global CO ₂ Initiative (2016)
<1.2 (aggregates)	Gomes et al. (2016)
5.3 (rocks)	Bide et al. (2014)
10 (aggregates)	Renforth (2011)
≤ 3.3 (aggregates) (2050)	Renforth (2019)
≤ 1.4 (construction materials)	Hepburn et al. (2019)



Carboncure

North America

- Introduces pure CO₂ into fresh concrete as it is poured
- Accelerates the hydration of the cement
- Reduces the amount of cement required
- CO₂ travels with the concrete mixer ready for injection
- To date 500,000 tonnes of CO₂ saved
- Uses c 1kg of CO₂ per tonne of concrete
- Allows concrete producers to use less cement

Carbonation Technologies Overview



Mine Tailings/ Ultrabasic rocks

Carbonation Technologies Overview

- Mineral Carbonation International (MCI)
- Carbonation of mining residues or ground olivines
- Wet carbonation process
- Currently has a pilot plant capable of processing a few 100t of CO₂
- Planning a demonstration plant capable of processing 50k tonnes
- Full scale plant converting 1 Mt of CO₂ on the drawing board
- Currently concentrating on the carbonation of nickel mining residues but can use other industrial residues through the demonstration plant
- The nickel tailing are serpentinite based and MCI are using the magnesium carbonate produced in plaster board or blocks

“By 2040, Mineral Carbonation International (MCI) wants to lock away 1 billion tonnes of CO₂ in building materials.”

Orbix & Carbicrete

Belgium, Canada

Orbix, Belgium

- Doing a variety of things with steel slags
- Slags ground to recover the residual metal
- Ground material pressed into blocks and carbonated in an autoclave at high temperature and pressure
- Also marketing Stinox and Carbogran granular materials, Fillinox, and Carbinox- fine grained materials the later able to absorb CO₂ from the air
- Based at the stainless-steel plants in Genk and Charleroi

Carbicrete, Canada

- Also making precast blocks
- Using steel slag based cements cured in CO₂

Carbonation Technologies Overview



Construction and demolition waste

- Several projects or companies making use of C&D waste to make Supplementary Cementitious Material (SCM)
 - Reduce the clinker in the cement
 - Partially driven by the reduction in availability of pfa from coal or GGBS from iron production
- Carbonation of the calcium silicates in the cement
 - produces calcium carbonate and a silica phase providing a limestone filler and pozzolan
- Alternatively carbonate the coarse RCA and improve water absorption for use in concrete

Blue Planet, Neustark, C2C4, Concrete for Change

Selling carbon credits in the VCM to fund projects

- Variable material – age and exposure
- In UK 95% of C&D waste recycled already
 - Difficult to separate the concrete from the glass, ceramics, brick etc.



Blue Planet North America

- Manufacturing an aggregate
- Using construction and demolition waste – crushed concrete
- Removing old cement paste from sand and gravel for reclamation
- Dissolving CO_2 in water/brine/ammonium salt and growing CaCO_3 on fine silica seeds
- Water-based capture solution
- CO_2 directly from flue gas

Carbonation Technologies Overview



Carbonation of Industrial Residues

Carbonation and Hard to Abate Industries

Energy from waste (EfW)

- Air Pollution Control Residues
- Incinerator Bottom Ash (IBA)

Steel manufacture

- BOF slag
- EAF and AOD stainless steel slag

Paper manufacture

- Biomass/Paper ash

Cement manufacture

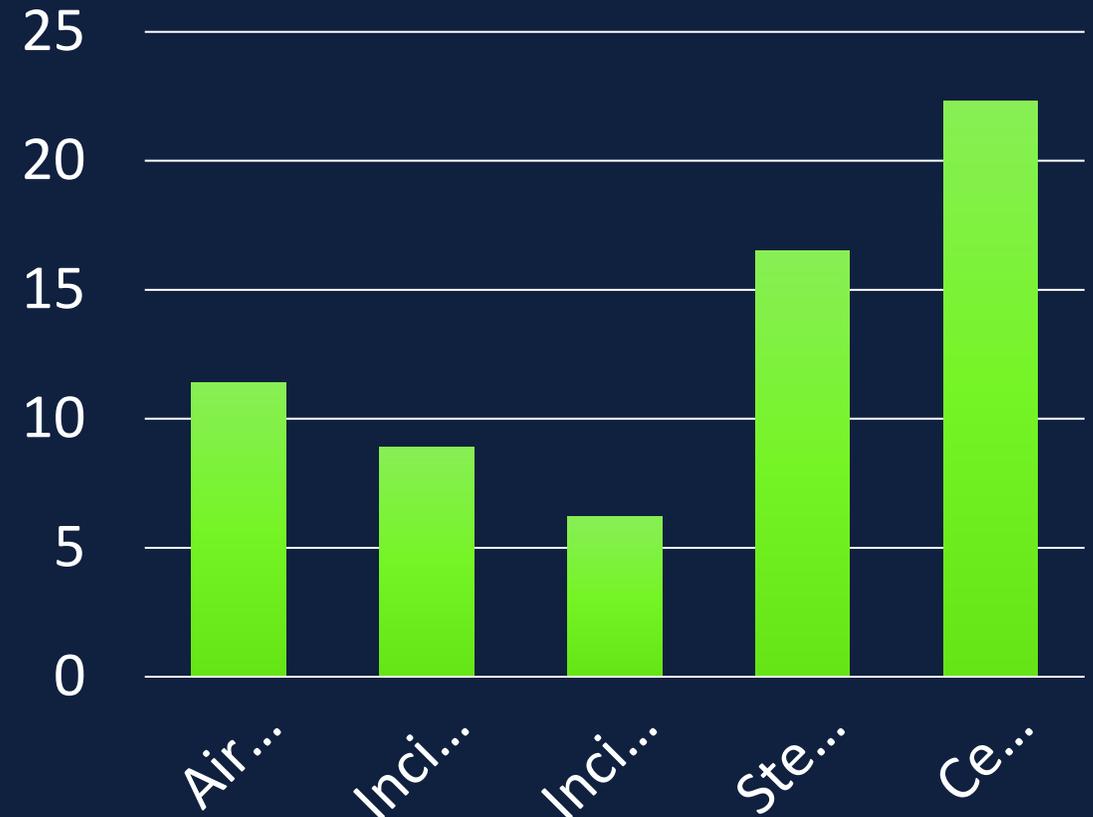
- Cement kiln dust CKD
- Cement by-pass Dust CBD

Recycled Concrete (C&D Waste)

Mine Tailings

- Ultrabasic and basic rocks

Percentage CO₂ uptake by weight



The CO₂ntainer

A Modular Solution to Industry Circularity

Main Features



CO₂ CAPTURE

Directly capturing and permanently storing 1,500 – 4,000 tonnes CO₂ per annum



12,000 TONNES

Industrial waste is upcycled per annum into new materials



SEAMLESS INTEGRATION

Minimal interference with production



100% AUTOMATION

Manual and automatic operation possibilities



CLOUD CONNECTED

Industry 4.0 capabilities



20 MINUTES

Safety captures and permanently stores CO₂ within 20 minutes



The CO₂ntainer at Vicat Group's cement plant in Montalieu, France

The Customer Value Proposition

Economic Carbon Capture and Circularity

Liabilities: Residues and CO₂, converted to assets



DIRECT COST SAVING

Divert residues from landfill with sustainable waste management and offset associated costs



CARBON FOOTPRINT REDUCTION

Permanently capture and safely store CO₂ directly from the source

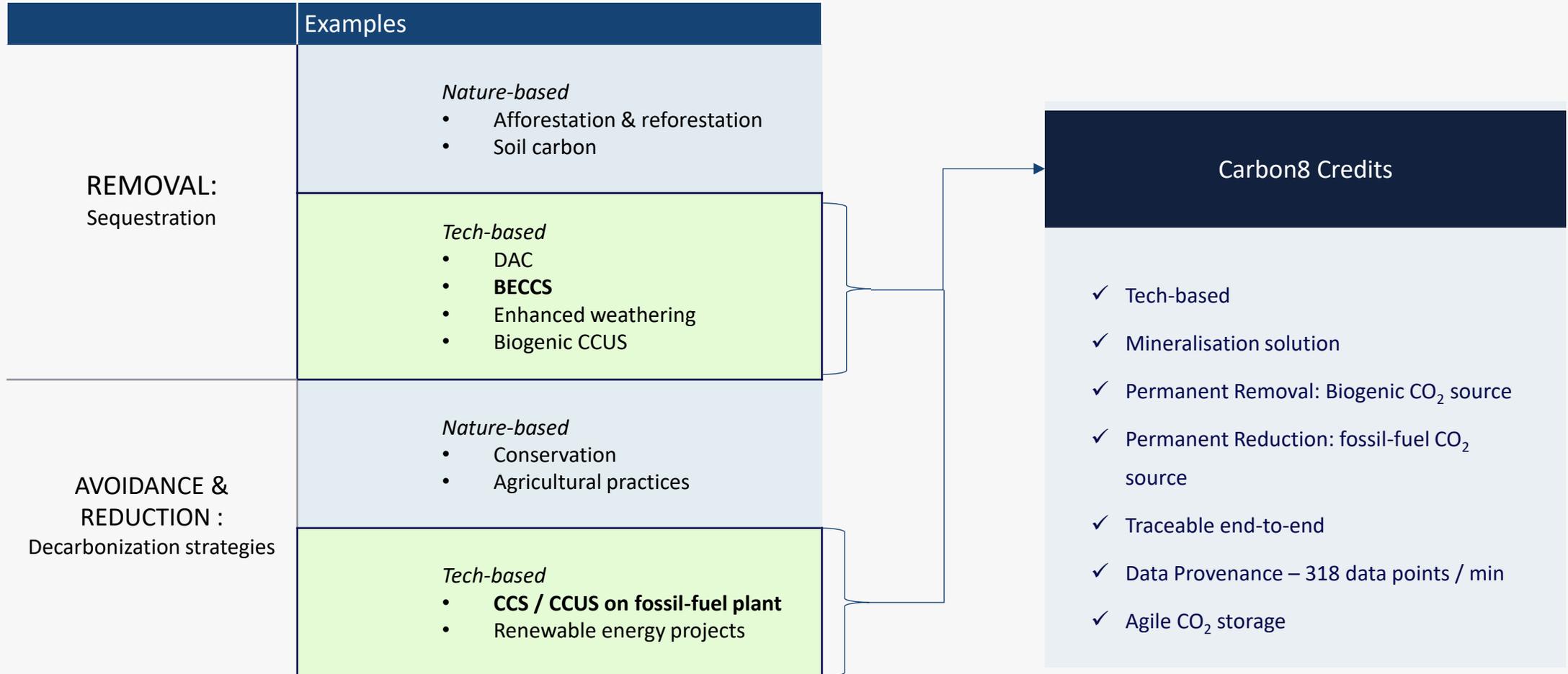


NEW CIRCULAR MATERIALS

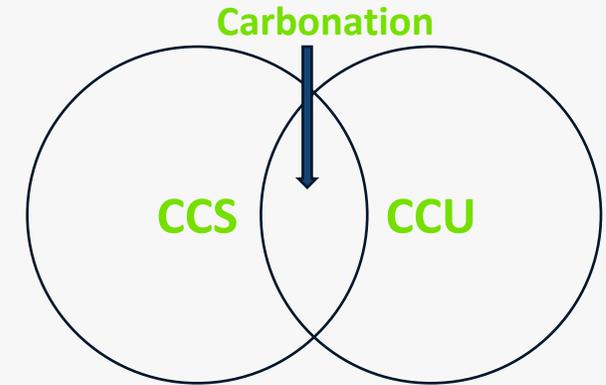
Enable circularity through implementing sustainable alternative building materials in production, or market them for a profit

Carbon Credits: Types and Classifications

Where does
Carbon8 Operate?



Summary and Conclusions

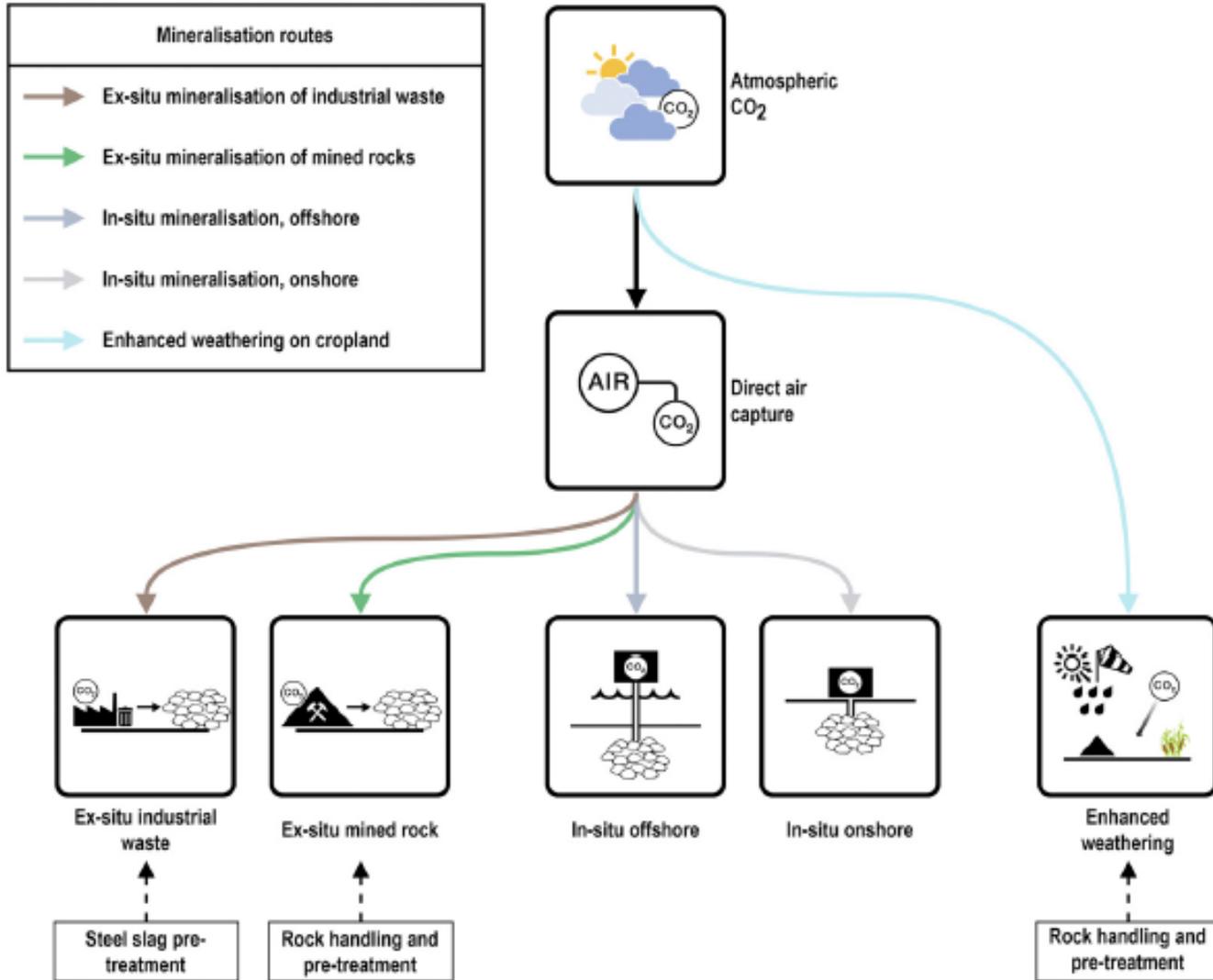


- Carbonation is a consistent negative emissions technology,
 - Low energy
 - Permanent
- Ex-situ utilization of CO₂ to produce construction products has the potential to capture >7 Gt of CO₂ per year by 2050
- Carbonation is agnostic with regard to the source of CO₂
- Easy to quantify the amount of CO₂ captured in products for carbon offsets or carbon credits
- Construction products are generally high volume/low value so sale of products difficult to overcome the cost of DAC
 - Better to retrofit carbonation systems to point sources of CO₂
- Need incentives to produce and purchase CCU products
- Need labelling and certification of mineralized products – reliable EPD's and LCAs



carbon8

Carbon Dioxide Removal (CDR) options with mineralisation (RSC 2024)



Cost and energy intensity of these options from 2030

- Insitu mineralisation;
 - ≤ 131 € per tCO₂
 - ≤ 11 MWh per tCO₂
- Exsitu mineralisation
 - ≤ 189 € per tCO₂
 - ≤ 3.7 MWh per tCO₂
- Enhanced weathering
 - ≤ 88 € per tCO₂
 - ≤ 1.1 MWh per tCO₂

Global deployment of these technologies based on DAC is assessed to require up to 0.21% of GDP to support 60% of CDR demand and 8.6% of primary energy demand. For 1.0 °C target for 2070

Presentation:

Overview of SAF technologies and pilot projects in the UK

David Blythe & Amy Ruddock,
Willis Lease





Willis Sustainable Fuels (UK) Limited – Introduction for

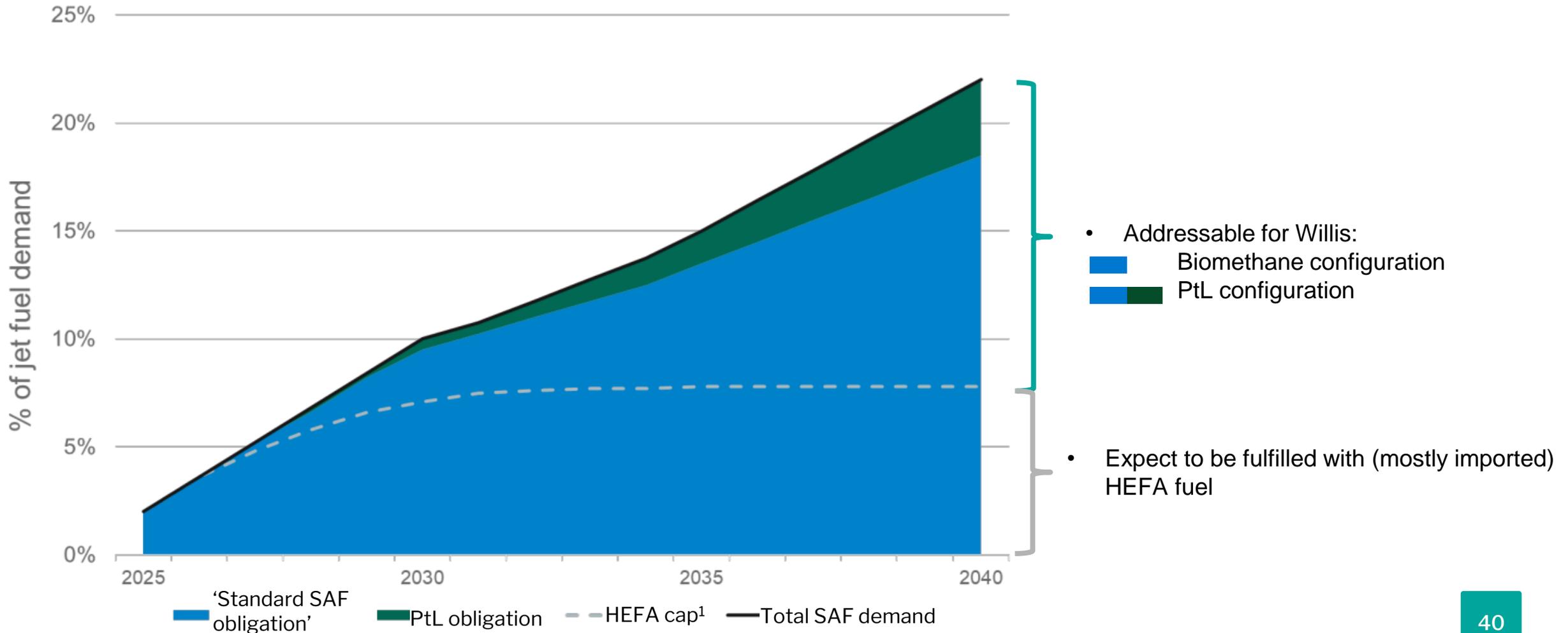


03 December 2024



Willis
Sustainable Fuels
(UK) Limited

THE UK SAF MANDATE SETS AMBITIOUS TARGETS FOR BOTH SAF AND PTL SAF. THE NON-HEFA¹ PORTION IS RELEVANT FOR WILLIS



1. See definition in the appendix
 Source: UKGov SAF mandate, April 2024; conversations with UK SAF industry players

Five SAF pathways

Source: BCG



BioSAF

eSAF

HEFA

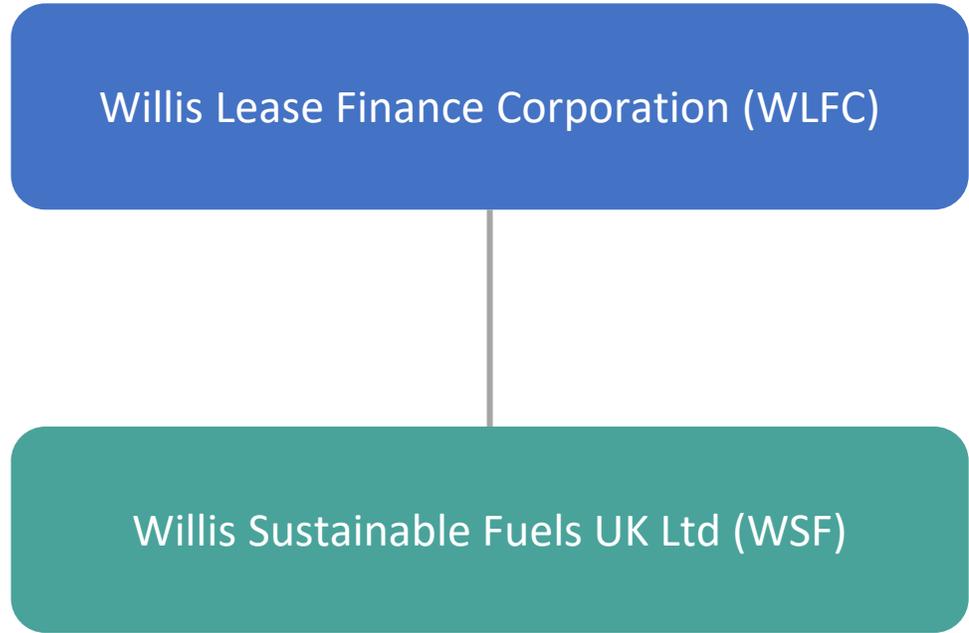
GtL

AtJ

MtJ

PtL





WSF is a project developer. We will develop, build and operate projects to decarbonise aviation, securing a future of flight for our customers

WLFC IS THE INDUSTRY LEADING INDEPENDENT ENGINE PLATFORM



A vertically integrated platform of related services driving lease origination, margin, and customer connectivity

Founded 1985

Book Value of Assets:

\$2.8bn
+9% YoY

RoE LTM:

18.8%

Engine & aircraft maintenance facilities, spare parts, and management & consultancy

NASDAQ listed 1996

344 owned and 222 managed engines

LTM EBITDA:

\$305m



PROJECT

- Teesside based
- Commercial demonstration of PtL-ready technology (CarbonShift)
- £4.7m from Advanced Fuels Fund Grant

PRODUCT

- 14,000 tonnes/year
- Fischer-Tropsch to ASTM D7566
- Biogas-to-liquid

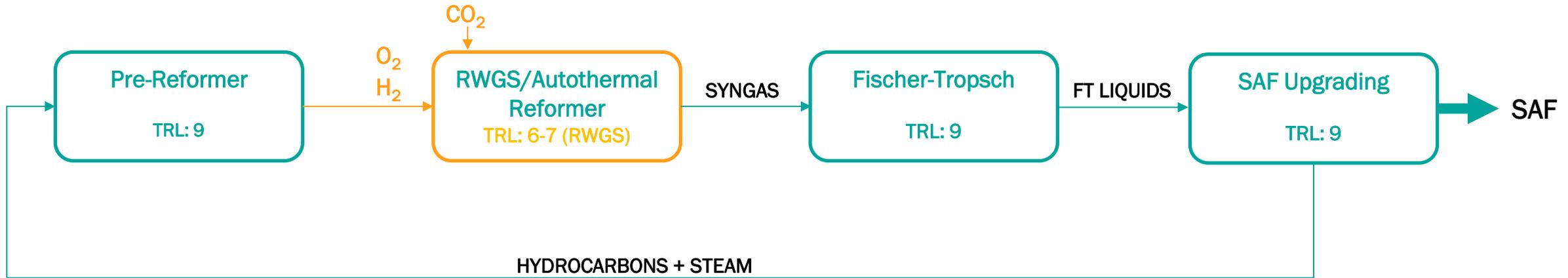
TIMELINE

- Early EPC detailed engineering work has started
- Target FID October 2025
- Targeted operations date – H2 2027
- Offtake on critical path to financing

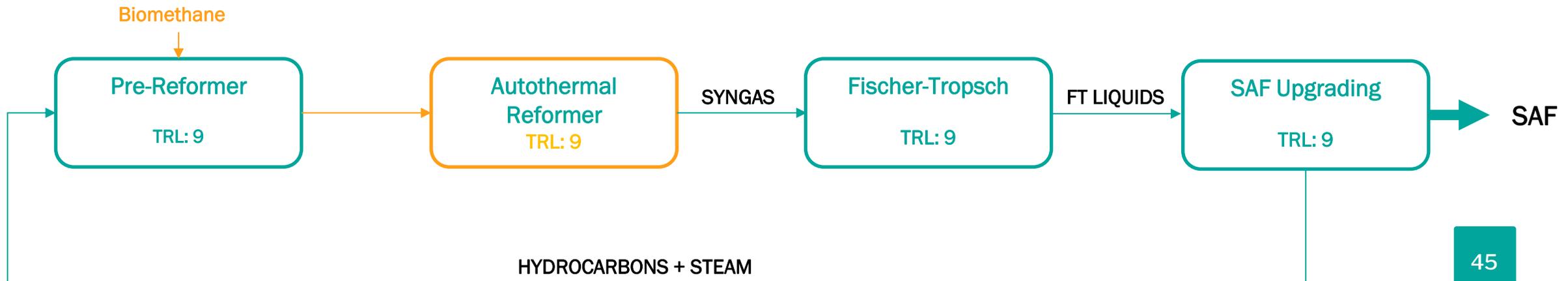


Orange indicates a difference

Power-to-liquid Configuration | TRL: High 7



Biogas-to-liquid Configuration | TRL: High 7



OFFTAKE FROM THE COMMERCIAL DEMO, ENABLES COMMERCIAL SCALE-UP of PtL



Commercial scale-up

- Ratio PtL: BtL to be determined by offtake need
- Target COD Q1 2030
- Target 70-140kT p.a.

Further deployment

Design one build many



Commercial demonstration

- 100% Biogas-to-liquid
- 14kT p.a.
- COD H2 2027
- Target 50% debt financing

Presentation:

Opportunity for CCS in UK EfW

Amelia Mitchell, ERM





OVERVIEW OF RECENT ERM REPORT

EfW with CCS: a key pillar for net zero in the UK

PRESENTED BY AMELIA MITCHELL

03/12/2024

Sustainability is our business

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ERM is at the center of CCUS and industrial decarbonization project delivery across the value chain



Commercial Feasibility

- Is concept economical
- Byproduct of marginal returns
- Breakeven CO2 volumes
- Transport & storage fee analysis
- Phased approach analysis
- Emission point technology selection
- Midstream infrastructure
- Subsurface data collection cost assessment



Financing & Business Development

- Grant application support with the DOE
- CCS lease application support in response to GLO RFPs
- 45Q tax credit monetization through IRS application & Measurement Reporting & Verification



Capital Project Delivery

- Early-stage planning through permitting strategy to site & route selection
- Feasibility, construction & environmental permitting
- Construction, performance testing & agency negotiations
- Operation, Title V permitting & spill remediation
- Closure



Social Capital

- Political & risk management
- ESG & social impact strategies
- Responsible value chain
- Just transition
- Strategic communications & reporting
- Stakeholder engagement
- DEI, human capital & employee engagement
- Human rights



Carbon Competitiveness & LCA

- Carbon accounting
- Decarbonization roadmap reconciliation
- Lifecycle analysis
- Product carbon footprinting
- Climate target alignment
- Pricing premium assessment
- Marginal abatement cost analysis
- Impact on enterprise value

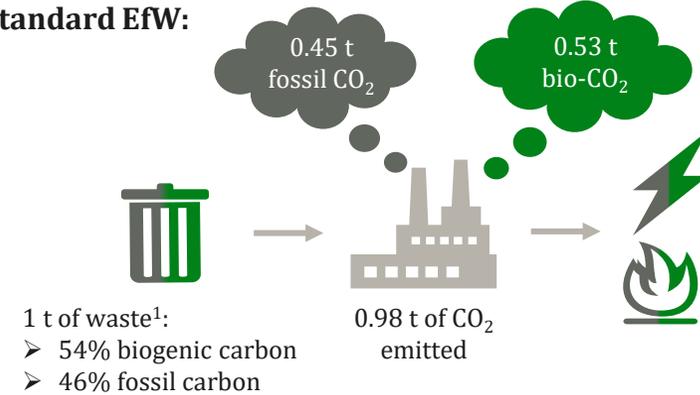
CCS is the only technology available to minimise EfW Scope 1 emissions, and generates valuable GGRs from biogenic CO₂ storage

ERM's new report, commissioned by Viridor, summarises the findings from our analysis, which included:

- assessing the **cost of carbon capture** for different Energy from Waste (EfW) assets
- assessing the **cost-optimal mode of transporting CO₂** to UK storage sites on an asset-by-asset basis
- defining **how deployment could be staged over time** as infrastructure and incentives develop using a multicriteria assessment and red-amber-green screening approach
- identifying **how CCS on EfW fits with UK net zero strategy and targets** (as developed by the UK government and its independent Climate Change Committee)

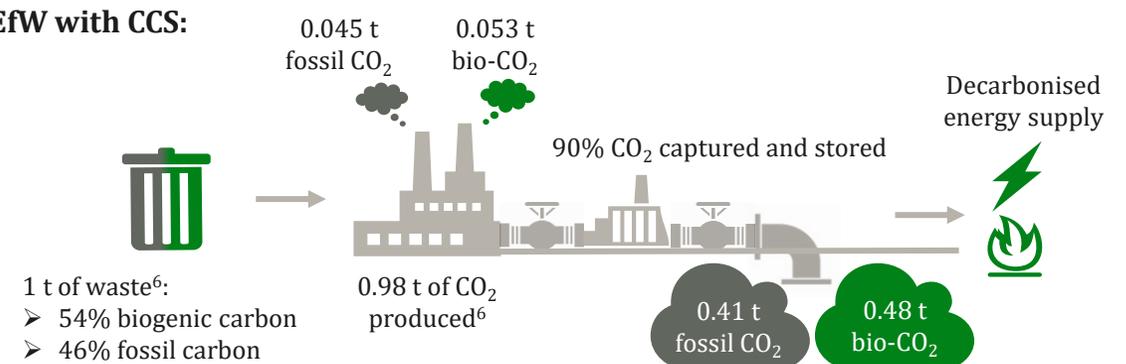


Standard EfW:



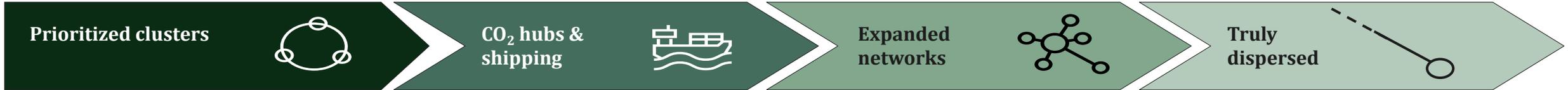
Analysis of UK waste statistics indicates **54% of residual waste sent to EfWs is of biogenic origin.**

EfW with CCS:



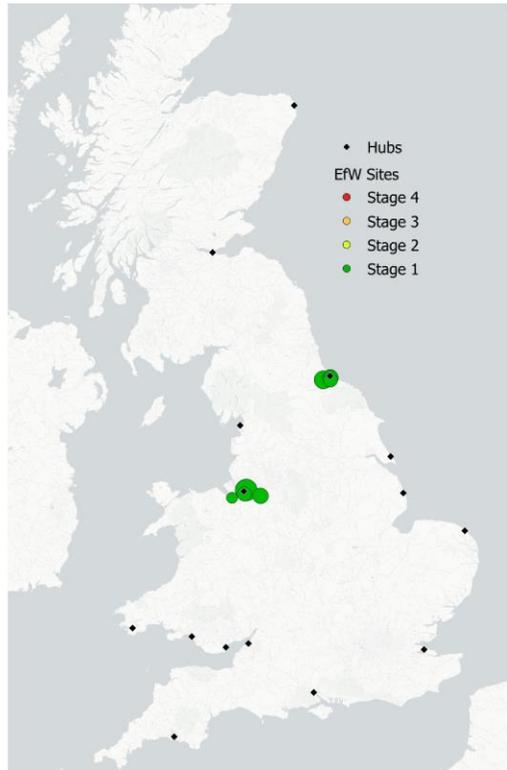
Permanent storage of CO₂ of sustainable biogenic origin is considered a **robust form of greenhouse gas removal.**

Four stages for CCS deployment across the EfW sector



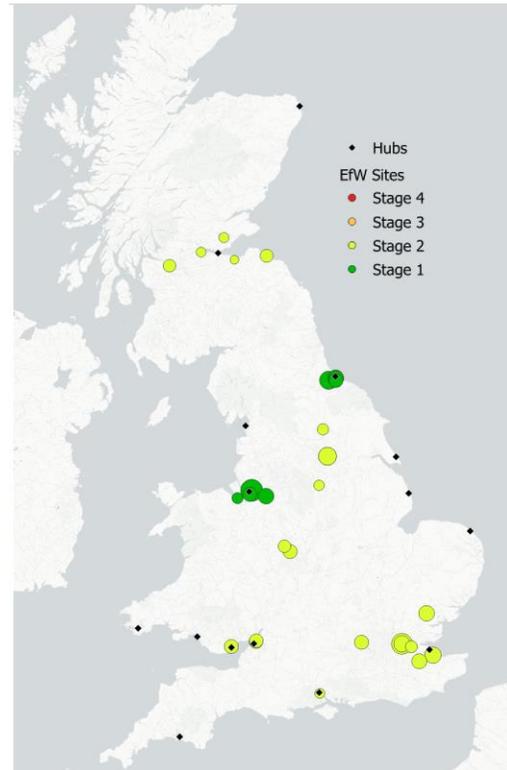
Stage 1

Eight large capacity facilities in strategic locations to directly connect to prioritized Track 1 cluster's CO₂ T&S infrastructure. This infrastructure is expected to be operational before 2030.



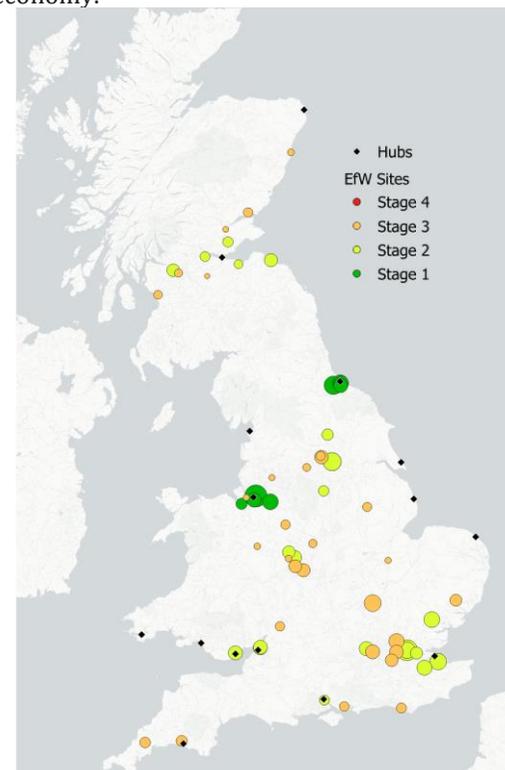
Stage 2

22 medium-large assets located <50km from CO₂ storage clusters or large ports that could become CO₂ shipping hubs - such as London & South East, South Wales, or Avonmouth - that could be operational by the mid-2030s.



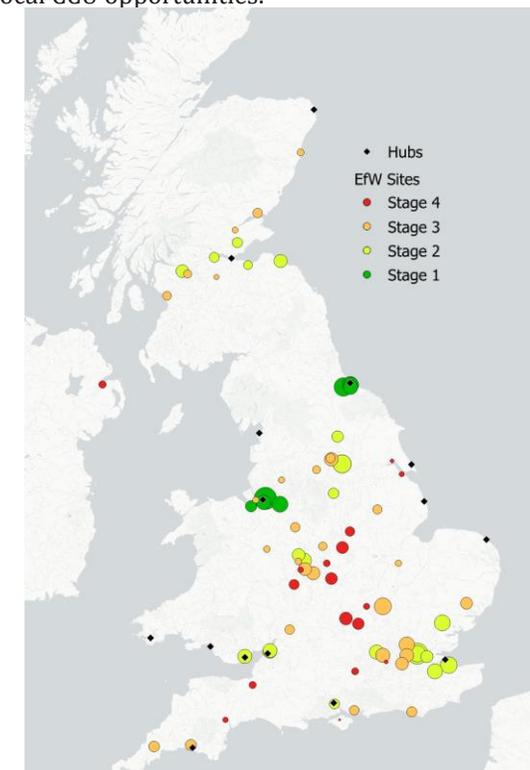
Stage 3

30 small-medium assets further from transport hubs. These sites may depend on CO₂ transport network expansion, potentially via rail, concurrent through the 2030s with the establishment of a multi-sectoral UK CCUS economy.



Stage 4

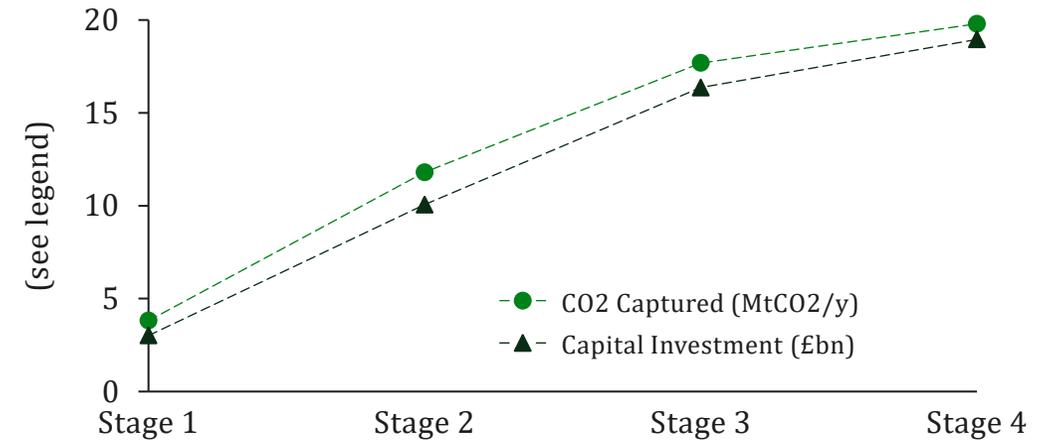
18 small and dispersed facilities, predominantly more than 100km from a CO₂ transport hub. Likely to be confined to asset relocation, aggregation, rely on inland CO₂ transport cluster formation, or investigate local CCU opportunities.



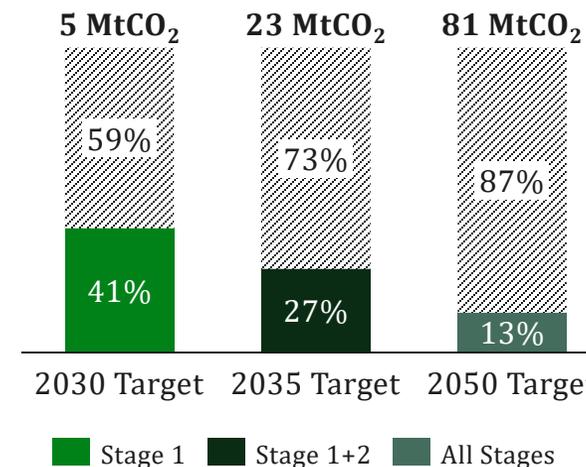
Capital investment of £19 billion with total capture potential of 20 MtCO₂ per year, contributing 27% of UK 2035 GGR target

- Uptake of carbon capture on EfW in the UK could capture up to **20 MtCO₂/y** and help **underpin the development of CO₂ transport and storage infrastructure**.
- Carbon capture and permanent storage (CCS) of CO₂ from EfW provides valuable greenhouse gas removals (GGRs) that could contribute **27% of the UK's 2035 GGR target** and enable a carbon neutral electricity grid.
- Deployment of CCS on EfW is anticipated in stages with an **estimated £19bn to be invested**, supporting the UK economy with potential to generate over **14,000 green jobs** and unlock nearly **£40bn in GVA**.
- CCS on EfW has a cascading impact of **reducing Scope 3 emissions across UK value chains**, and lowering household carbon footprints.

Cumulative impact of deploying CCS on EfW in the UK



Contribution that CCS on EfW's could make to UK government GGR targets



£19.0bn
capital investment opportunity



£38.8bn
GVA delivered



4,800
construction jobs on average until 2040

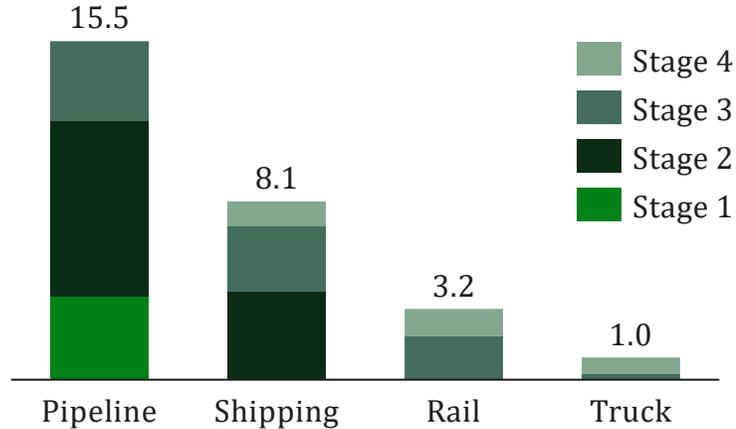


9,350
permanent green jobs

Non-pipeline modes enable transport of 54% of CO₂ captured from the EfW sector

- 54% of EfW emissions require non-pipeline transport to minimise the cost of CCS
- **CO₂ shipping supports 41%** of decarbonisation by enabling assets far from storage clusters to connect via shipping hubs. These deployments are made within **Stage 2** of deployment.
- Rail also plays a major role, enabling decarbonisation of almost 20% of EfW emissions. This is deployed in **Stage 3**.

Total CO₂ transported by transport method, split by deployment stage (MtCO₂/y)



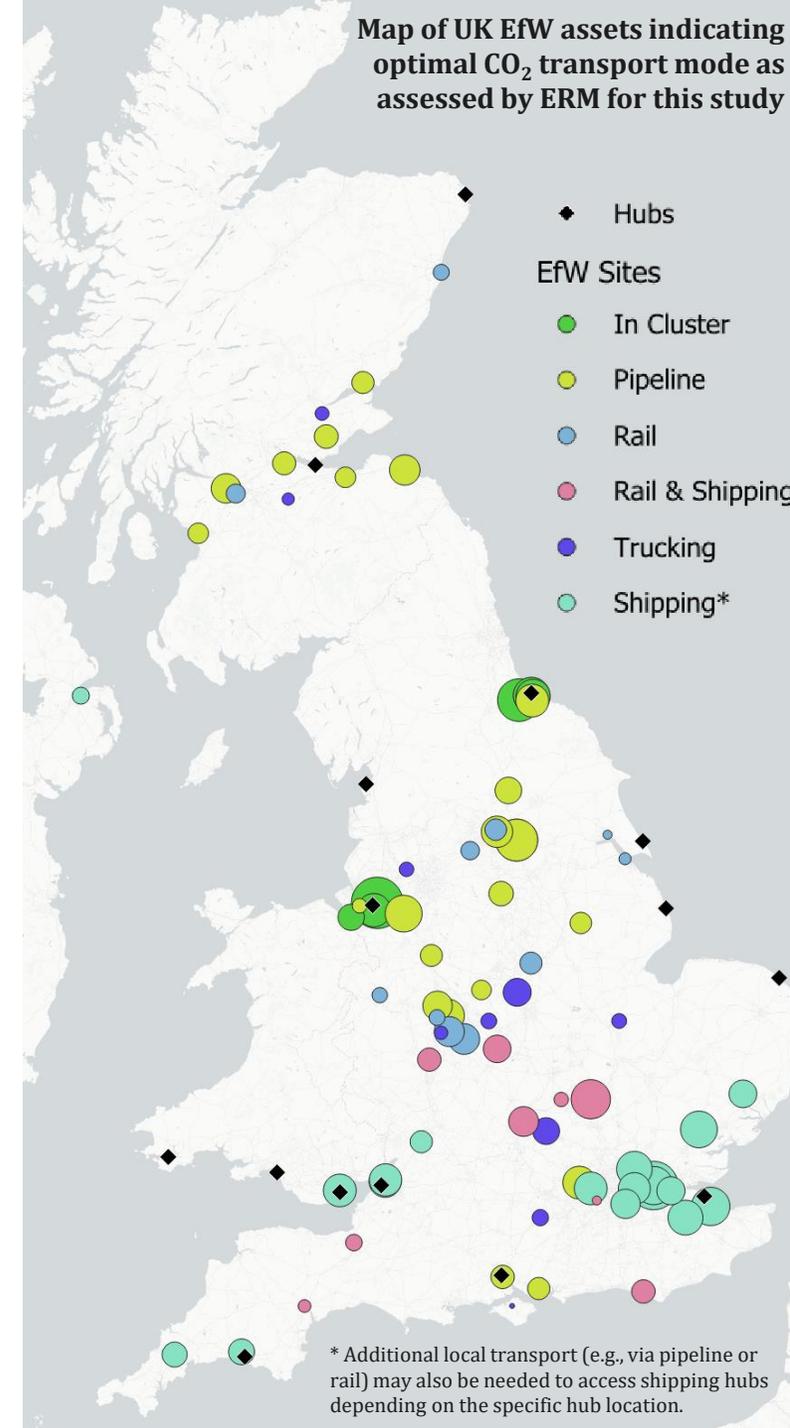
8.1 MtCO₂ transported by ship from hubs such as London & South East and Avonmouth to storage sites, requiring **investment in 8 ships** for CO₂ shipping (each 18 ktCO₂ capacity).



3.2 MtCO₂ transported by rail connecting a total of 20 dispersed EfW sites to CO₂ hubs across the UK. Analysis found that **67% of EfW sites are within 1km of a rail network**.

CO ₂ Shipping Hub	Number of EfW plants	EfW capture capacity (MtCO ₂ /y)
London & South East	15	5.4
Avonmouth	7	1.7
Plymouth	3	0.5
Other	3	0.5

Map of UK EfW assets indicating optimal CO₂ transport mode as assessed by ERM for this study



* Additional local transport (e.g., via pipeline or rail) may also be needed to access shipping hubs depending on the specific hub location.

The EfW sector is already progressing on this journey

- **Six of the UK's EfW assets located near prioritised hubs for CO₂ storage have already announced CCS plans** and applied to the government's CCUS Cluster Sequencing competition.
- The government is currently in **negotiations with two EfW assets, Protos ERF and Viridor Runcorn**, to receive funding for CCS deployment and be operational by 2027.
- A total of **30 EfW assets are well-placed to deploy CCS by 2035**, laying foundations for the development of more CO₂ hubs and rapid decarbonisation of the waste sector.
- Next steps require the **connection of other suitable EfW assets to Teesside and Merseyside hubs**, the further **development of CO₂ hubs** (e.g., Grangemouth, Humber), and the development of hubs for **CO₂ shipping** (e.g., London & South East, Avonmouth).



Thank you

If further information is required,
please contact:
Amelia.Mitchell@erm.com

Report available at:
<https://www.erm.com/efw-with-ccs-a-key-pillar-for-net-zero-in-the-uk/>

AOB & Conclusions

- Review actions arising from meeting
- Next Working Group Meeting: **March 2025** (date TBC)
- AOB

