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THE ASSOCIATION FOR RENEWABLE ENERGY & CLEAN TECHNOLOGY

Carbon capture at green gas plants: market overview and challenges

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With input from:

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The Bioeconomy Consultants NNFCC

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How we represent AD and green gases

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GreenGas CERTIFICATION SCHEME

Biofertiliser certification scheme

HYDROGEN

REA H_2 WORKING GROUP: *Moving the hydrogen agenda forward*

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Current CO_2 demand and supply

Ensus bioethanol plant, Teesside

UK industry use:
~600,000 tonnes CO_2 per year (FDF, 2019)

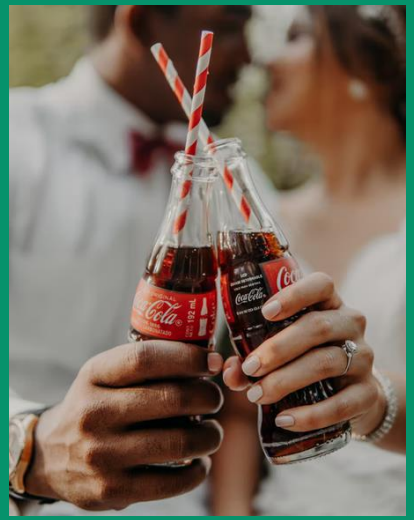
Around 60% of this gas demand is supplied by two *CF Fertiliser* factories producing ammonium nitrate:

- Billingham, Teesside *(largest supplier)*
- Ince, Cheshire

Most of the remaining gas is supplied by:

- Nippon's fertiliser plant in Rotherham (around 45%)
- Ensus' bioethanol plant in Teesside (can provide up to 40%)

CO_2 recent shortages



- In September 2021:
  - CF Fertilisers suspended production at its plants in Ince near Ellesmere Port and Teesside due to rising energy costs as global gas prices spiked.
  - UK Government provided 'limited financial support' (3 weeks) towards CF Fertilisers' running costs to prevent a food supply shortage in British supermarkets.
- CO_2 industry then came to a number of agreements to ensure UK businesses have access to a sustainable supply of CO_2.
- In the longer term, the government said would like to see the market take measures to improve resilience, and they are engaging on ways this could happen.

Bio-CO_2 capture at green gas plants

1. Compression and water removal
2. Purification column
3. Liquefaction of purified product

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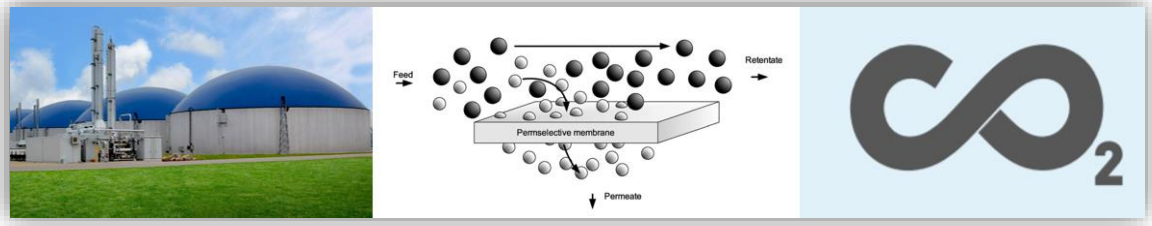
- ~100% CO_2 can be captured at biomethane plants.
- Technology exists and is proven.
- Currently **11 biomethane plants** already capturing bio-CO_2 from the biogas upgrading process.
- These plants supply around **80-90,000 tonnes** bio-CO_2 to industry per year (~15% demand).

The Air Liquide CO_2 Tanker is an Existing Food Grade Example (Not Manure)



Source of image, CNG Services, 2022

Biomethane and CO_2 capture: the process

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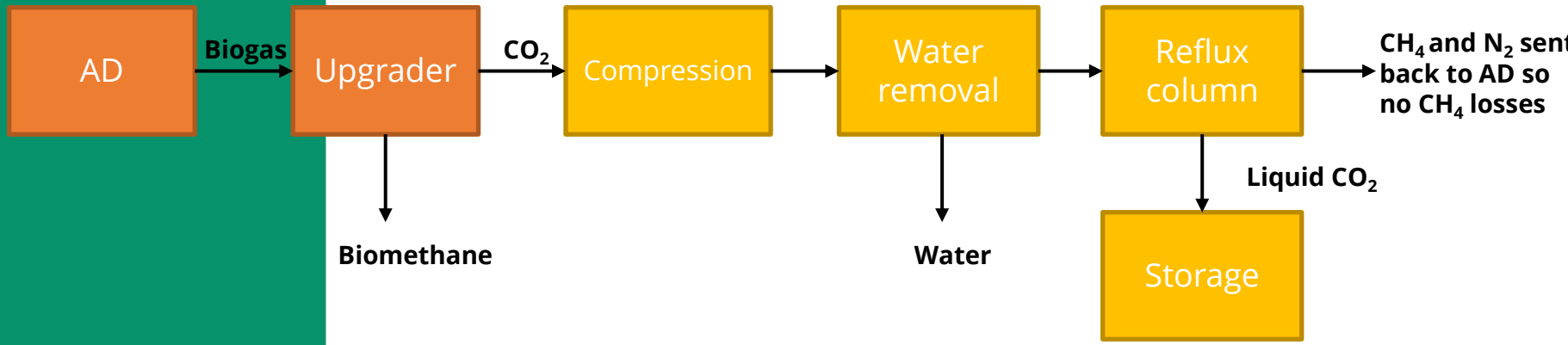


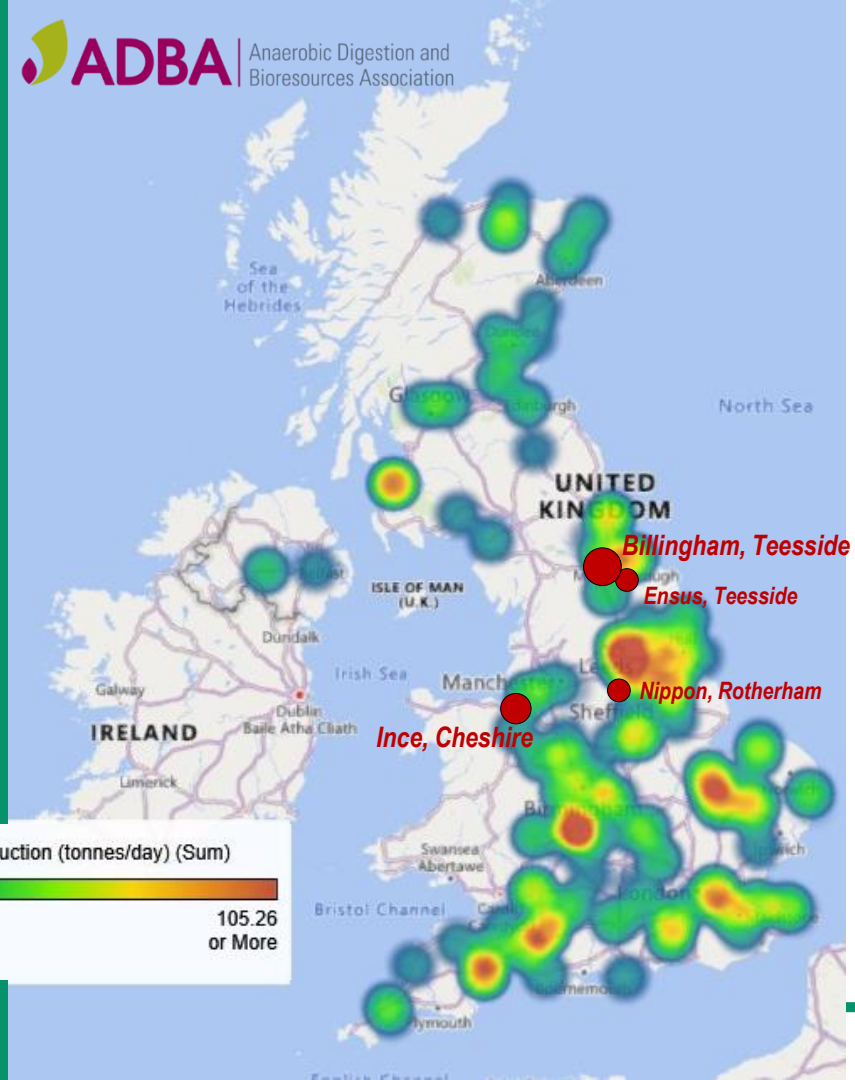
The above diagram shows a rough outline of the process route for transforming CO_2 from biogas upgrading into liquid CO_2 (LCO_2)

Biomethane industry potential

- *107 operational biomethane plants* in the UK, treating municipal, industrial and/or agricultural feedstocks (NNFCC, 2022)
- Another *12 waste-water facilities* (NNFCC, 2022)
- At least **70 plants** could retrofit it easily.
- Average plant in the UK (40 GWh) produces ~ **7,300 – 8,000** tpa of bio-CO_2.
- **Industry could currently yield around 500,000 – 600,000 tpa of bio-CO_2 which could meet current demand.**

The Bioeconomy Consultants
NNFCC

Distributed and diversified source of bio-CO_2



*AD plants offer a **decentralised supply** of bio-CO_2*

Coloured areas on the map display all locations within a **25km radius** of every biomethane plant in the UK.

Locations in red could source 100+ tonnes of bio-CO_2 per day from local AD infrastructure.

Green Gas Support Scheme (GGSS)

In November 2021, BEIS launched the GGSS.

- This scheme rewards the production and injection of biomethane from AD plants through a fixed tariff rate (p/kWh), secured for 15 years.

Before the end of 2025, the GGSS is forecast to:

- Support the construction of **~45 new plants** with an average biomethane capacity of >750 m^3/h
- At this size, each plant would produce ~ **9,200 tonnes bio-CO_2 per year** (~ 25 tonnes per day)

It is expected most of these plants will deploy upgrading technology capable of producing **food-grade CO_2.**

Wastes

• Under the GGSS, at least **50% of the biogas** must be derived from wastes or residues. So, this will be all waste-derived CO_2.

Biomass gasification

The RadGas technology converts household waste into biomethane, biohydrogen or liquid fuels without any emissions to air and minimal solid residues.

It provides a simple pathway for chemical recycling of waste that fits within the vision of a circular economy.

absl
advanced biofuel solutions ltd

ABSL plants

Swindon demonstration project

- Development of the Swindon plant start in 2015.
- The world's first facility to thermally convert household waste into biohydrogen/BioSNG
- Converts 1,000kg per hour of waste wood or refuse derived fuel in 200kg of green gas and 800kg of carbon dioxide.
- Biomethane is injected into the grid and sold to CNG and LNG filling stations.
- ***6,000 tpa of CO_2 once it is fully operational***

Commercial plant at Protos

- Another 15x larger commercial plant is being developed with Progressive Energy at the Protos Energy Park in Cheshire.
- 350 GWh/year of BioSNG and hydrogen from 133,000 tonnes per annum of refused derived fuel (RDF), using same technology.
- ***Protos will produce around 100,000 tonnes per annum of CO_2***– to be in operation in 2025 – 27.
- Another four plants being planned.

Air Liquide

Bio-CO_2 current markets

- Food & beverage companies – dominant market.
- Other markets: abattoirs, glasshouses etc.
- In light of recent CO_2 shortages, demand and prices have gone up though this could be temporary.

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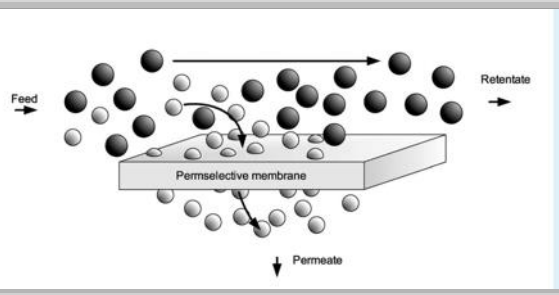

Key barriers to deploying carbon capture at biomethane plants

- Key issues identified by biomethane sector are mainly:
  - Market perception towards waste-derived CO_2
  - Cost of installing and running carbon capture technology

Negative market perception of waste derived CO_2

The Air Liquide CO_2 Tanker is an Existing Food Grade Example (Not Manure)

- Limited market acceptance for **waste derived liquid CO_2** from food & beverage companies:

  - ✓ Entirely due to perception - waste derived CO_2 can meet the same spec (Food-grade CO_2) as non waste CO_2.
  - ✓ Middle size industry not particularly concerned, it's mostly the big companies (e.g. Coca Cola) that have an issue
  - ✓ In contrast with Government policy which aims at encouraging more biodegradable wastes to AD, diverting them from landfill and supporting a Circular Economy.

Economics

- **High capex** of installing / retrofitting a CO_2 liquefaction plant:
  - ✓ Unit production costs are significantly higher compared to large scale fertiliser plants due to limited economies of scale. Scale is an important factor as biomethane installations are typically not large enough, nor produce enough CO_2, to make the investment stack at current CO_2 market prices.

- **High opex**:
  - ✓ Running costs can be very significant due to the high-power demand from the equipment used to capture the CO_2.
  - ✓ Electricity is required for the CO_2 liquefaction process – estimated at an additional 0.1kWh/Nm^3 biogas processed

- **Limited number of bio-CO_2 offtakers** - there is limited price competition:
  - ✓ Some CO_2 companies have pulled out from the sector or were not interested in the first place because they regarded production at each facility as too small.

Regulatory position for using CO_2 in the food industry

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Defra and the EA have clarified that:

- Any CO_2 that meets the classification of 'food-grade', as defined by the FSA via reference to the *food additive specification in the Commission Regulation (EU) 231/2012*, is suitable for use in the food sector.

  ✓ Alternative specifications: ISBT and EIGA

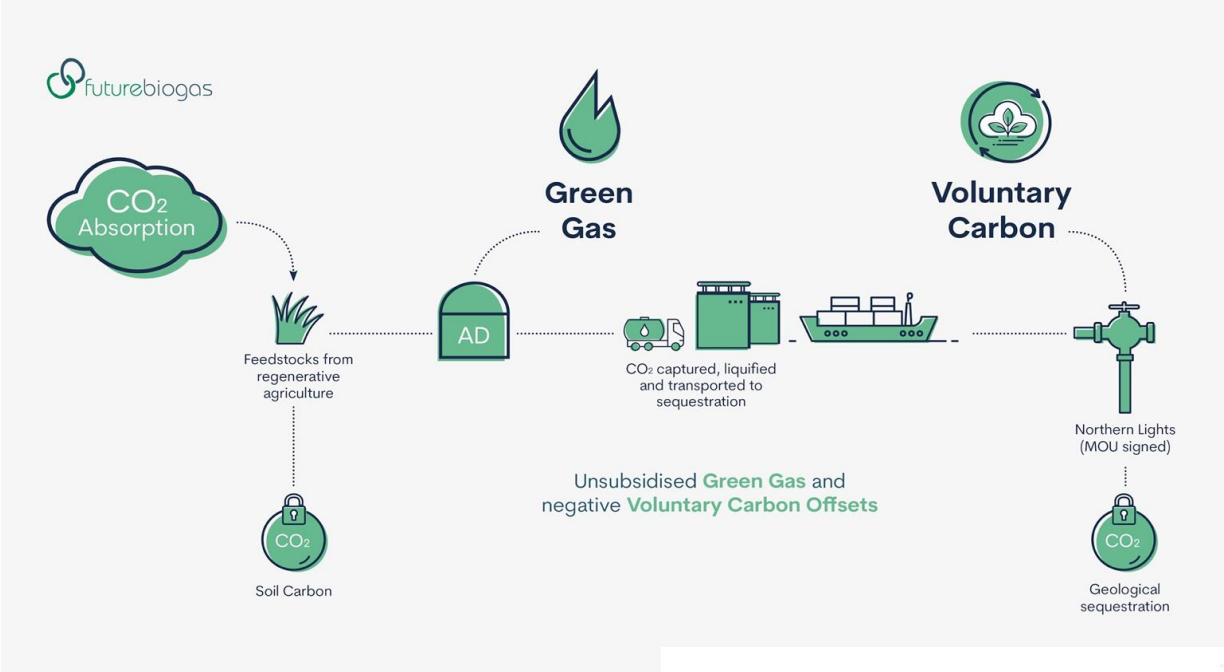
- No regulatory or legislative concerns on CO_2 from waste or sewage management as long as it meets above specs.

- CO_2 recovered from biogas that meets the FSA food-grade specifications would also in principle meet 'end of waste status'.

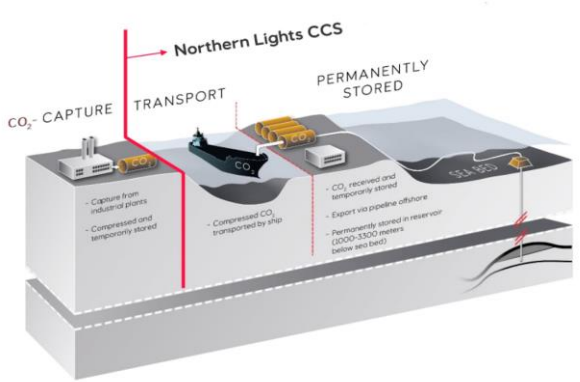
- The process for recovering CO_2 on site must not present a risk to the environment or human health. EA currently issuing a Regulatory Position Statement on permitting requirement for the process of capturing CO_2 .

- Companies must ensure they comply with relevant H&S legislation (storage of compressed gas)

Will bio-CO_2 be locked away in the future?



futurebiogas



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Impact of net zero policies on CO_2 availability to F&D sector

Current key CO_2 sources	Available in the long term?	Net zero policy or market levers
Ammonia production	- Green ammonia (electrolytic hydrogen, no CO_2) - Blue ammonia (blue hydrogen, CCS	- UK ETS - Other incentives to switch to clean hydrogen (net zero funds, business models etc.)
Bioethanol production	Bioethanol production plus CCU or CCS?	- Government policies to incentivise GGRs / negative emissions / BECCS
Biomethane (AD)	Biomethane plus CCU or CCS?	- Government policies to incentivise GGRs / negative emissions / BECCS - Other incentives to support clean hydrogen production (HBM, RTFO etc) - Voluntary negative carbon offset market
	Biomass gasification (ATT/ACT) or SMR of biogas, with CCU or CCS?	- Government policies to incentivise GGRs / negative emissions / BECCS - Other incentives to support clean hydrogen production (HBM, RTFO etc). - Voluntary negative carbon offset market
	Blue hydrogen (SMR/ATR + CCS) [500kte/y of CO_2 per plant, which would satisfy the whole market.	- UK ETS - Other incentives to switch to clean hydrogen (net zero funds, business models etc.)

Thank you

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