BIOGENIC CO_2 FROM AD

CARBON CAPTURE, STORAGE & UTILISATION

PENTAIR futurebiogas

ADBA

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FOREWORD

Achieving global net zero emissions by 2050 to limit global warming to 1.5˚C is a crucial challenge of our era. The upcoming COP 28, in just a few months, will unveil the magnitude of the task ahead. During the conference, the United Nations' global carbon stocktake will be presented, highlighting the disparity between countries' commitments to decreasing carbon emissions and their actions taken.

To maintain a safe global temperature, an increase of no more than 2˚C (ideally 1.5˚C), global scientists say the level of atmospheric carbon should not exceed 618 ppm (507 ppm)[i]. It currently stands at 417ppm[ii].

Against this background, we are thrilled to endorse the Biogas Insight briefing by ADBA, which sheds light on how anaerobic digestion can offer carbon capture solutions.

Photosynthesis is the most effective method of removing CO_2 from the environment[iii]. With the help of anaerobic digestion (AD), CO_2 can be recovered and recycled from organic wastes produced along the food chain[iv]. Currently, the production of food is responsible for 31% of global greenhouse gas emissions, from farm to fork. But by integrating AD and its by-products we can significantly mitigate a proportion of this and drive down emissions throughout the value chain while positively contributing to food security.

This recovered CO_2 can either be stored or utilised for other purposes. Pentair is collaborating with Future Biogas to develop a BECCS (bio-energy carbon capture and storage) pathway for AD operators, by storing bio-CO_2 within sub-sea geology.

Continued >

References:

[i] How much CO_2 at 1.5°C and 2°C. **Met Office**

[ii] Greenhouse gases continued to increase rapidly in 2022 **NOAA**

[iii] 6 Ways to Remove Carbon Pollution from the Atmosphere **WRI**

[iv] Plants Buy Us Time to Slow Climate Change – But Not Enough to Stop It **Berkeley Lab News Center**

[v] New FAO analysis reveals carbon footprint of agri-food supply chain **UN News**

FOREWORD CONTINUED

CO_2 is a strategically important gas in the manufacturing industry, especially in the food production sector. Traditionally, the majority of CO_2 has been sourced from the production of mineral fertilizers, which heavily rely on fossil fuels[vi]. To assist in mitigating the emissions associated with fertiliser production, biogenic CO_2 captured through AD can be considered a viable option.

Additionally, the UK Minister for Food recently expressed concerns at the beginning of the year about the UK's dependence on imports, which leaves us susceptible to shocks and vulnerable situations[vii].

Pentair has developed technologies for biogas upgrading and carbon capture utilisation, recycling them to produce sustainable biomethane (the equivalent of natural gas) and liquid carbon dioxide (CO_2). Pentair's experience in CO_2 purification to meet a variety of stringent specifications, such as those in carbon capture, shows the path toward a diversified use of carbon.

According to the UN[viii], using AD and biogas technology is a fast and cost-effective way to meet the goals of the Paris Agreement. The Biogas Insight report from ADBA highlights the significant impact that the AD industry can have when fully utilised[ix].

David Hynes, Sales Manager Biogas Upgrading & CO_2 Recovery Systems, Pentair

References:

[vi] Falling flat: lessons from the 2018 UK CO_2 shortage **Food & Drink Federation**

[vii] CO_2 shortages: Food minister calls for fresh government intervention **The Grocer**

[viii] Global Methane Assessment **UNEP**

[ix] Tackling methane emissions the key to averting climate catastrophe, says UN **WBA**

EXECUTIVE SUMMARY

The transition to Net Zero will require the UK to remove CO_2 from the atmosphere while simultaneously preventing CO_2 emissions through reduced fossil fuel consumption.

AD represents the most immediate and cost-effective means of achieving this, through either BECCS (bioenergy carbon capture and storage) or BECCU (bioenergy carbon capture and utilisation).

This Briefing illustrates the role AD can play in both decarbonising the atmosphere by replacing fossil natural gas and CO_2 with biomethane and bio-CO_2.

ADBA would like to thank Pentair and Future Biogas for their support in the production of this briefing.

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NOT ALL CARBON IS EQUAL

The emission of carbon dioxide (CO_2) does not always contribute to greenhouse gas (GHG) emissions – it depends on where the carbon originates from…

Carbon dioxide CO_2

Fossil

Originating from fossil resources

Carbon is derived from geological stores, where it has been locked away from the atmosphere for millions of years.

Release of fossil-CO_2 contributes to greenhouse gas emissions

✗ Carbon emissions

Biogenic

Originating from living organisms

Carbon is derived from the atmosphere, where CO_2 is absorbed by plants during photosynthesis.

Release of bio-CO_2 does NOT contribute to greenhouse gas emissions

✓ Carbon neutral

FOSSIL CARBON VS BIOGENIC CARBON

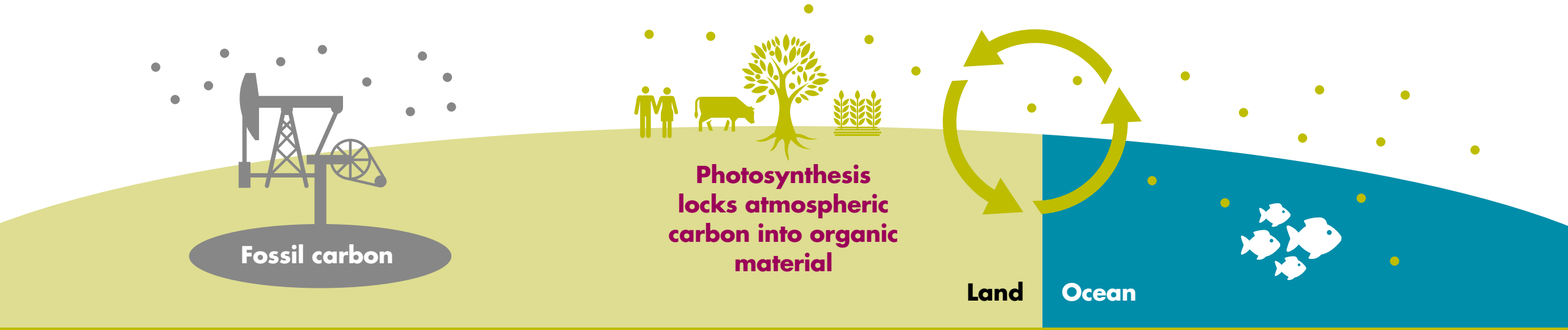
Carbon is a crucial building block to all life on earth.
However, its increasing concentration in the atmosphere is driving climate change.
To tackle climate change, we must consider **where this carbon is coming from** and **what form it is in**.

Fossil carbon

For millions of years carbon has been locked away deep underground. The extraction and use of fossil fuels releases this carbon into the atmosphere.

Natural carbon cycle

Biogenic carbon is derived from living organisms – atmospheric carbon is assimilated into plants and passed on through the food chain. Biogenic carbon is recycled through organic processes.



CARBON CAPTURE WITH AD

All organic matter contains biogenic carbon – such as:

All organic matter can be recycled via anaerobic digestion (AD)

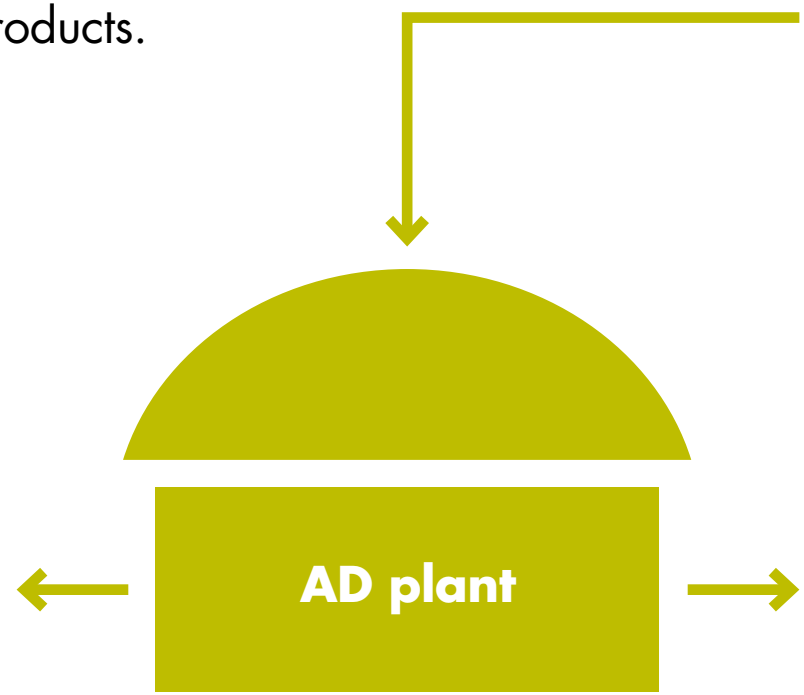
AD uses microorganisms to break down organics within sealed tanks (i.e., without oxygen present, or 'anaerobic').

This process concentrates biogenic carbon within the tank.

CAPTURING BIOGENIC CARBON FROM AD

Composed of biogenic carbon, organic feedstocks are brought to AD plants. Here, the AD process converts these feedstocks into two sustainable products.

Organic feedstocks



Product 1 **Biogas**

Biomethane ~55% **Bio-CO_2 ~45%**

Both gases – biomethane (bio-CH_4) and bio-CO_2 - are chemically identical to their fossil equivalents, **biogenic** and **carbon neutral**.

Product 2 **Biofertiliser** (or 'digestate')

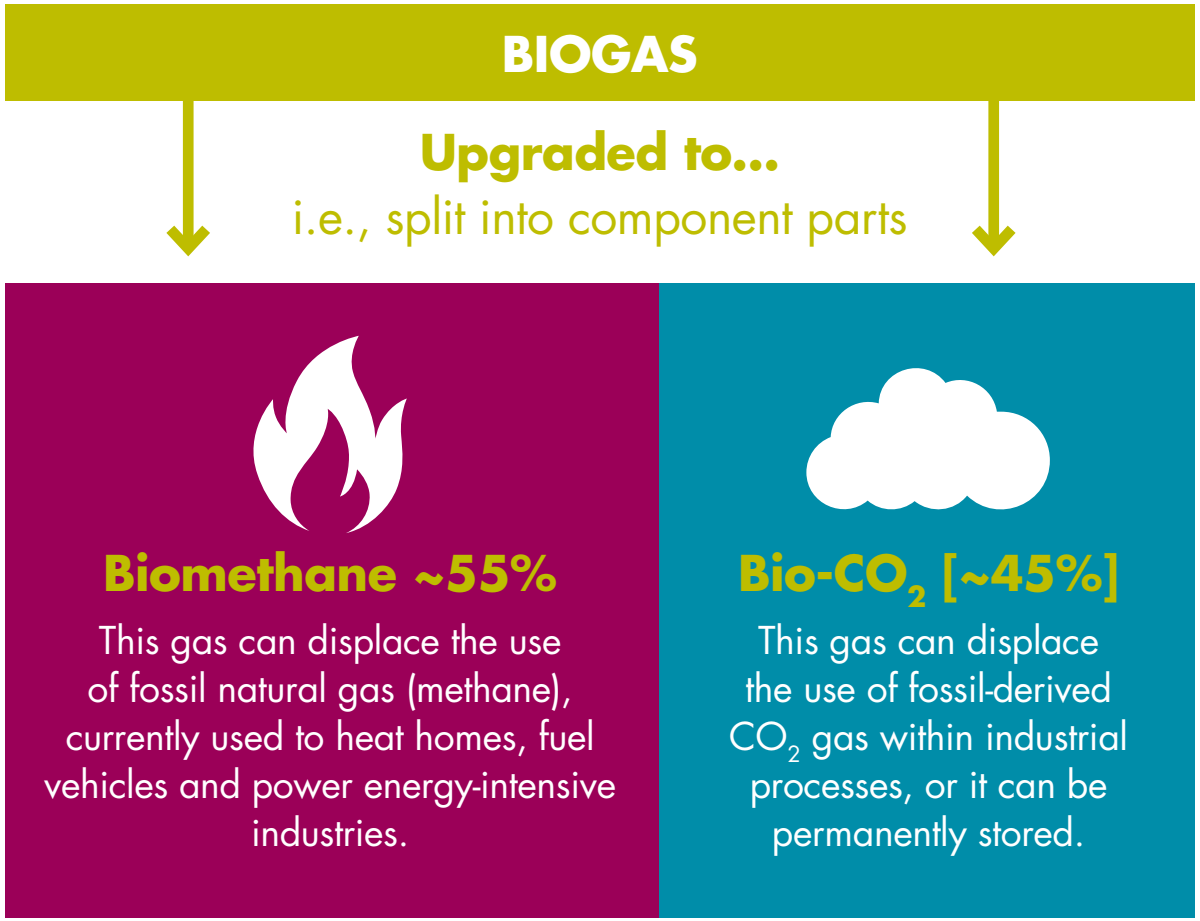
Remaining solid material from the digestion process can be used as an organic fertiliser. Spread to land, it recycles minerals and nutrients from the feedstock and can improve the ability of soil to sequester carbon, away from the atmosphere.

PRODUCING BIO-CO_2

Biogas can be 'upgraded' into biomethane by splitting the gaseous mix into its component parts.

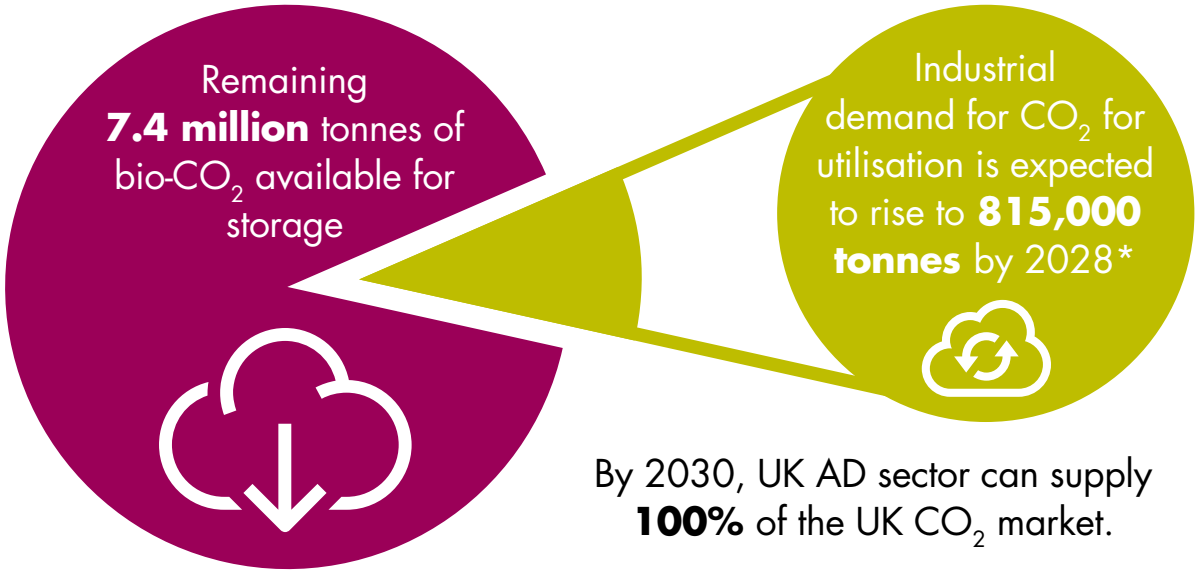
Current government support incentivises the production of biomethane, due to its ability to decarbonise the gas grid. However, the process also creates a concentrated stream of bio-CO_2 gas.

This sustainably sourced by-product can be used in industrial processes or permanently stored, acting to remove GHGs from the atmosphere – i.e., **reversing emissions**.



CCS FROM AD AT FULL POTENTIAL

At full potential, where all unavoidable and collectable organic wastes are recycled via AD, by 2030 the sector can produce **54.5 TWh** of energy and around **8.3 Mt** of bio-CO_2 for storage or use.



By 2030, UK AD sector can supply **100%** of the UK CO_2 market.

- Reduce the UK's carbon emissions by **6%**
- Save **23 $MtCO_2eq$** of GHG emissions
- Treat **170 million tonnes** of organic waste

Benefits of capturing and storing CO_2

- Mitigate GHG emissions from fossil fuels
- Reduce facility's carbon footprint
- Deliver targets from Global Methane Pledge
- Reduce emissions from the fertiliser industry

*UK CO_2 Market Report and Forecast

CCS FROM AD AT FULL POTENTIAL

As of June 2023, the UK has 133 biomethane plants with the potential to capture **1 million tonnes** of bio-CO_2

600,000 tonnes represents the UK's annual industrial demand for CO_2...

...which the AD sector alone could meet, leaving an additional **400,000 tonnes** of CO_2 to be stored.

The GGSS aims to stimulate an additional 2.7 TWh of biomethane per year, which would increase the CO_2 recovery by a further **400,000 tonnes**.

REVENUE STREAMS FROM BIO-CO_2

Increase the Sustainability Criteria

Capturing CO_2 increases the sustainability of plants by reducing process emissions, which in turn can increase the value of biomethane certificates.

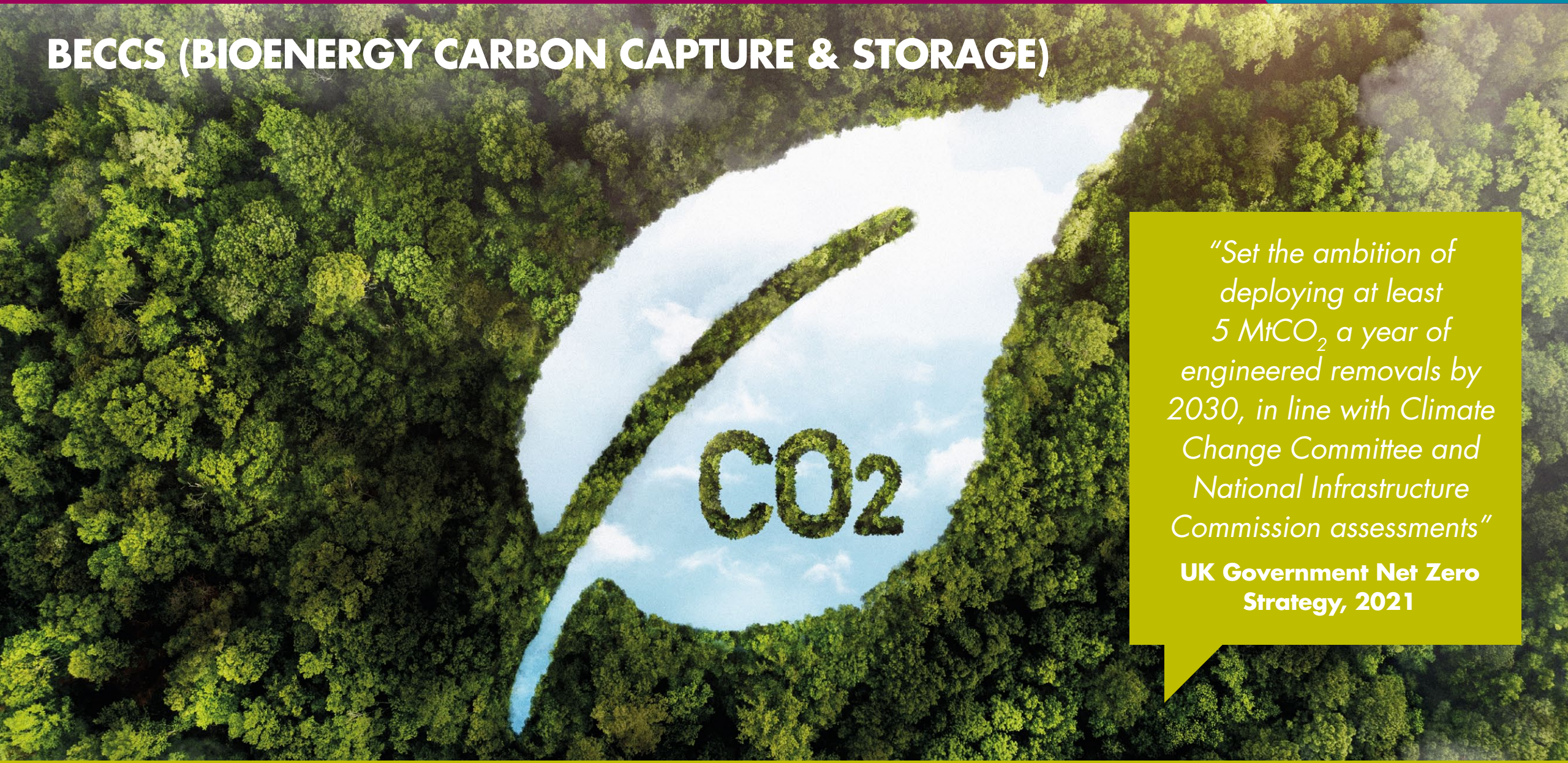
Sell your Carbon for Utilisation or Storage

Industrial demand for secure supplies of CO_2 has recently surged, along with the emerging storage markets, opening up new markets for bioCO_2. This is set to grow as BECCS increasingly comes to market.

Sell Carbon Credits

AD plants that capture CO_2 can generate revenue by selling carbon credits or offsets to individuals, businesses or governments seeking to reduce their carbon footprint.

BECCS (BIOENERGY CARBON CAPTURE & STORAGE)



"Set the ambition of deploying at least 5 $MtCO_2$ a year of engineered removals by 2030, in line with Climate Change Committee and National Infrastructure Commission assessments"

UK Government Net Zero Strategy, 2021

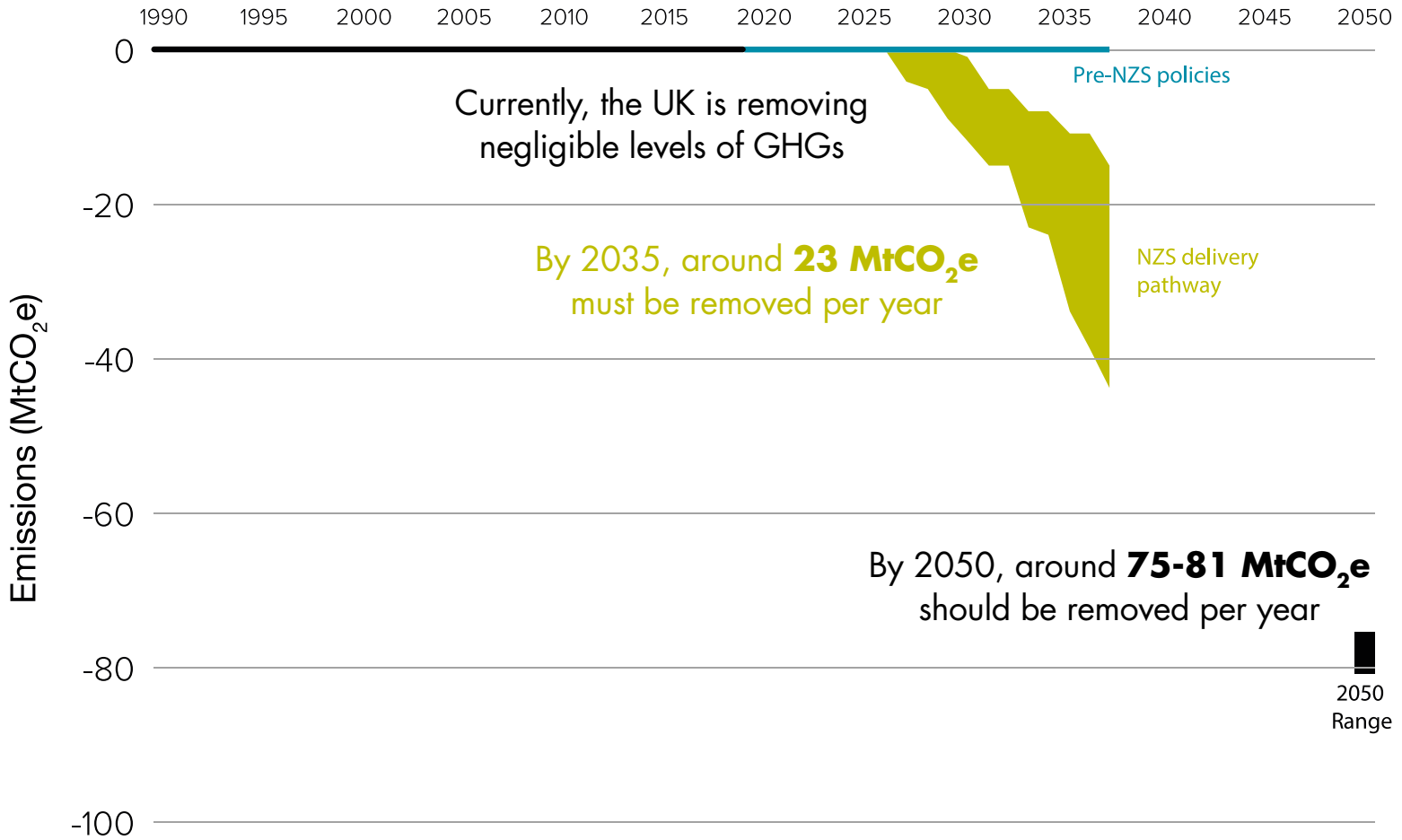
GREENHOUSE GAS REMOVAL (GGR)

To deliver Net Zero by 2050, simply reducing emissions is not sufficient.

The UK must seek ways of capturing greenhouse gases from the atmosphere and permanently storing them.

An estimated **75-81 $MtCO_2e$** will need to be removed from the atmosphere every year to deliver Net Zero.

Taken from the government's **Net Zero Strategy (2021)** **https://bit.ly/3xXmVlH**



AD'S ABILITY TO DELIVER GREENHOUSE GAS REMOVAL (GGR)

During the biogas upgrading process, the UK's existing fleet of biomethane plants produce around **1.0 Mt** of bio-CO_2 every year – all of which is suitable for capture and storage.

If we include CHP plants in the mix, the AD industry could generate **2.5 Mt** of bio-CO_2 per year.

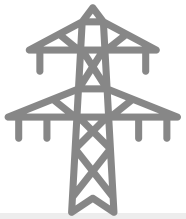
By 2030, the AD sector has the potential to capture and store an estimated 8.3 Mt of bio-CO_2...

...contributing 10% to the government's GGR target for Net Zero.

PATHWAYS AVAILABLE FOR GGR

There are two principal mechanisms for actively removing greenhouse gases from the atmosphere:

DACCS
Direct Air Carbon Capture and Storage



Energy-intensive technology filters CO_2 out from the air

100% renewable electricity is required to deliver carbon removals via DACCS.

BECCS
Bioenergy with Carbon Capture and Storage

Biomethane can be used for energy

Photosynthesis captures atmospheric CO_2 and fixes it into plant cells

AD

Organic feedstocks composed of atmospheric carbon taken to an AD plant

Atmospheric CO_2 can be captured and stored

Bio-CO_2 can be captured and stored

Geological storage
100s of metres below surface.

CO_2 concentration is 1000x greater inside an AD tank, compared to the open air. AD additionally creates a nutrient-rich biofertiliser capable of returning carbon to soils.

PATHWAYS AVAILABLE FOR GGR CONT.

The Business Case

Governments around the world are putting forward ambitious actions to support and incentivise investment in GGR technologies.

Joining the race, the UK government commits to developing a GGR business model and providing **revenue support for negative emissions**, to achieve the ambitious targets set by the Net Zero Strategy.

In addition, the UK government intends to:

- Develop Negative Emissions Contract for Difference to accelerate investment
- Consider integrating GGRs into the UK ETS (emissions trading scheme)

These plans can support businesses to capitalise on carbon capture and help generate revenue by selling carbon credits to the large emitters

EMERGING CCS PROJECTS

The UK has access to several CCS projects in development, looking to establish CO_2 networks. While these projects aren't specifically for AD, if bio-CO_2 producers are able to access these networks then there is a major opportunity to develop a storage market.

HyNet North West The HyNet North-West helps decarbonise the industrial sector by capturing and storing CO_2 below the seabed. This storage project aims to store up to 10 million tonnes of carbon emissions a year by 2030.

Source: **HyNet North West**

Northern Endurance Partnership The Northern Endurance Partnership is currently working on developing offshore infrastructure for transporting and storing CO_2 from the East Coast industrial sector. This storage project aims to store up to 10 million tonnes of CO_2 a year by 2030.

Source: **BEIS**

Northern Lights Northern Lights is a carbon storage project backed by the Norwegian government, to permanently store CO_2 under the North Sea. The project has the capacity to transport, inject, and store up to 1.5 million tonnes of CO_2 per year, by mid-2020s.

Source: **European Commission**

BECCU (BIOENERGY CARBON CAPTURE & UTILISATION)

"[CO_2 is a strategically important gas.] The UK's dependence on imports leaves us susceptible to shocks and vulnerable situations"

Mark Spencer MP, UK Minister for Food, 2023

CO_2 GAS DEMAND

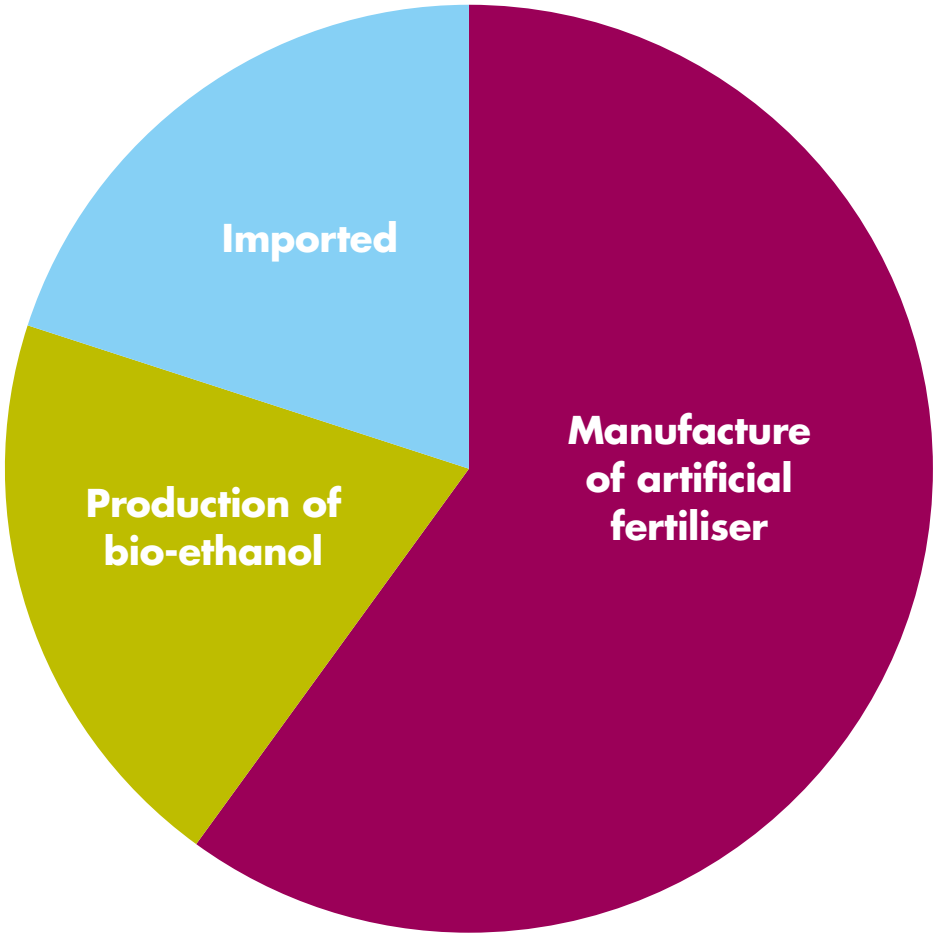
UK industries use around **600,000 tonnes CO_2 every year.** While most (50-60%) is used in the food and drink sector, e.g., to carbonate fizzy drinks, CO_2 is also utilised in various other sectors.

The demand for CO_2 from alternative sources has been increasing recently due to the gas and fertiliser crisis…

…and it will continue to increase, as companies recognise the ability to store carbon within new products, such as using CO_2 to cure **concrete**, and bio-CO_2 could provide the biogenic carbon required within the next generation of fuels, such as **SAF** (sustainable aviation fuel).

Taken from **Food and Drinks Federation (2019)** **https://bit.ly/3yrGaFi**

CURRENT CO_2 SUPPLY



The majority of the UK's CO_2 gas demand is supplied from the manufacture of artificial fertiliser (~60%).

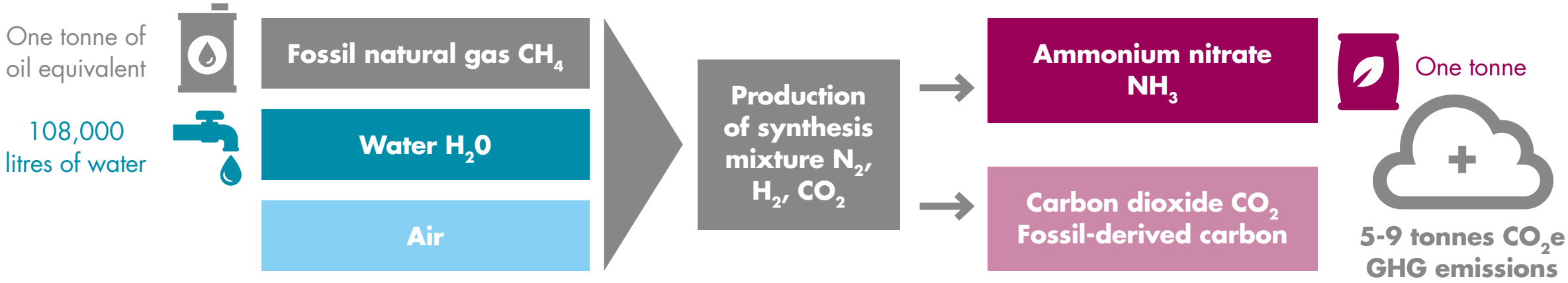
Here, fossil natural gas is converted into ammonium nitrate, a compound which provides plants with the nitrogen (N) necessary for growth.

CO_2 gas is produced as a by-product of this energy-intensive artificial process.

Taken from **Food and Drinks Federation (2019)** **https://bit.ly/3yrGaFi**

CARBON INTENSITY OF CURRENT CO_2 SUPPLY

To create ammonium nitrate, a core ingredient of artificial fertilisers, factories deploy the Haber Bosch process. Manufacturing **one tonne of ammonium nitrate** requires the following:



This process is incredibly energy- and carbon-intensive. Global Ammonia production is responsible for **1.3%** of all man-made emissions (**WEF**), and according to The Royal Society's **Policy Briefing on Ammonia**, the production process uses **~1.8% of the world's total energy supply**.

NB: By recycling nutrients found within organic wastes, AD also creates a biofertiliser known as digestate. Spreading digestate can displace the need for artificial fertilisers, helping to decarbonise agriculture and reduce water pollution.

CO_2 SUPPLY CHAIN VULNERABILITY

The recent gas crisis has highlighted vulnerability in the existing CO_2 supply chain

High levels of natural gas are required to manufacture fertilisers – when its price increases, so do the cost of artificial fertilisers and CO_2 gas. In early June 2022, CF Fertilisers UK shut its Ince manufacturing plant near Chester, where production had been suspended since September 2022 in response to rising gas prices. Ince was one of the UK's largest mineral fertiliser production plants.

Now, traditional supplies of industrial CO_2 gas produced within the UK comes from just two plants;

Name	Industry process	CO_2 production capacity
Billingham, Teeside	Artificial fertilisers	400 kt
Ensus, Teeside	Bio-ethanol production	250 kt*

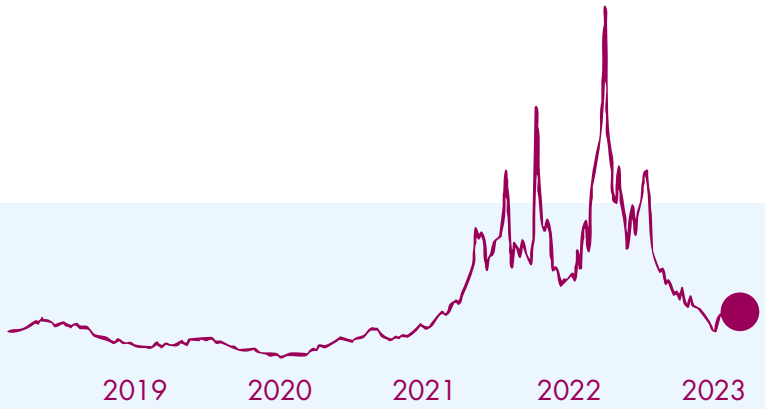
*Despite a high capacity, relatively low demand for bio-ethanol means the plant has been closed for long periods since opening in 2010

Taken from **Food and Drinks Federation (2019)** **https://bit.ly/3yrGaFi**

CO_2 PRICE SENSITIVITY

2021/22

Over the last 15 years, the gas price has averaged around **50p/therm**.



Gas price (p/therm) June 2023 **81.06p**

From early 2021, **gas prices began increasing rapidly** as a result of a particularly cold winter in 2020/21 which diminished gas stores, a relatively windless summer which increased gas demand for electricity generation and increased global gas demand.

In December 2021, the gas price reached its first record-breaking peak at nearly **450p/therm**. Three months later, this record was beaten again, peaking at **540p/therm**. While the gas price remained above 165p/therm, from September 2021 to January 2023, it has come down significantly in the first 2 quarters of the year. Currently, the gas price looms at **80p/therm** which is still challenging compared to the pre-crisis levels.

At elevated prices, it is not economical for artificial fertiliser plants to operate, as they require vast quantities of natural gas. Consequently, both Billingham and Ince plants went offline – **cutting off CO_2 production and supply**.

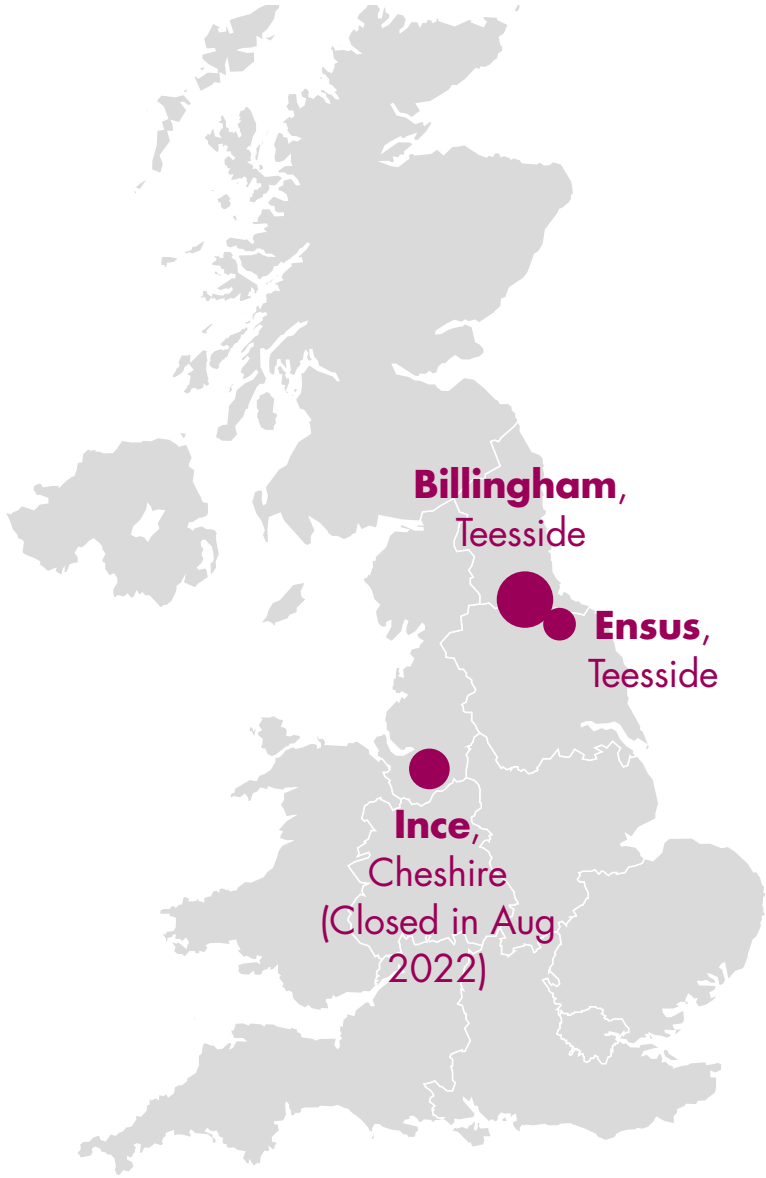
Twice the UK government paid CF Fertilisers UK to maintain production to secure CO_2 supplies. It has never disclosed how much. Simultaneously, CO_2 off-takers, particularly in the food and beverage industry, were advised to find alternative, secure supplies of CO_2.

CO_2 PRICE SENSITIVITY CONT.

In the current centralised nature of CO_2 supply, its price is largely determined by the users' proximity to major production plants.

To prevent tank contamination, trucks typically return to production sites empty, which **doubles** the mileage, fuel cost, and labour cost needed to transport one batch of CO_2.

Long-distance transport of CO_2 is not economical and leads to high life cycle emissions.



BIO-CO_2 PRODUCTION

AD plants could supply bio-CO_2 for industrial use, providing a sustainable alternative to fossil-based sources.

As of June 2023, there are **133 biomethane plants** in the UK:

120 plants treat municipal, industrial and/or agricultural feedstocks

Total bio-CO_2 production = **897,000 tonnes pa**

Average plant production = **7,500 tonnes pa**

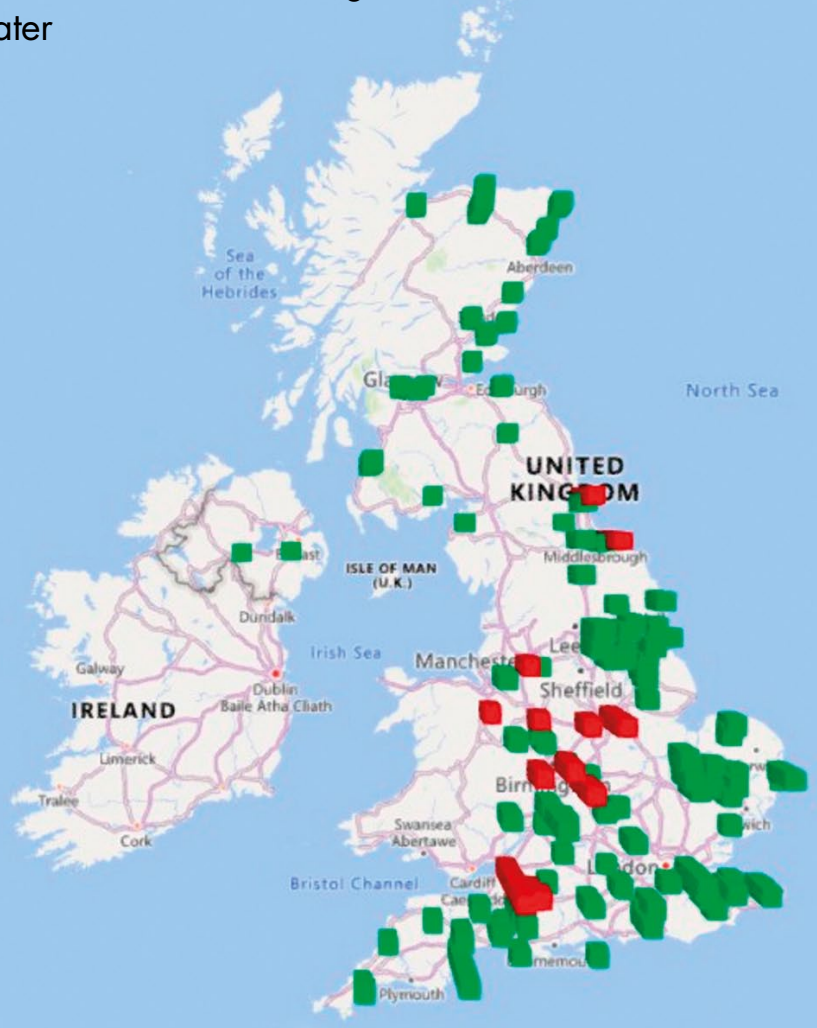
13 plants treat wastewater

Total bio-CO_2 production = **157,000 tonnes pa**

Average plant production = **12,000 tonnes pa**

Bar height proportional to plant size

- Municipal, industrial and/or agricultural
- Wastewater



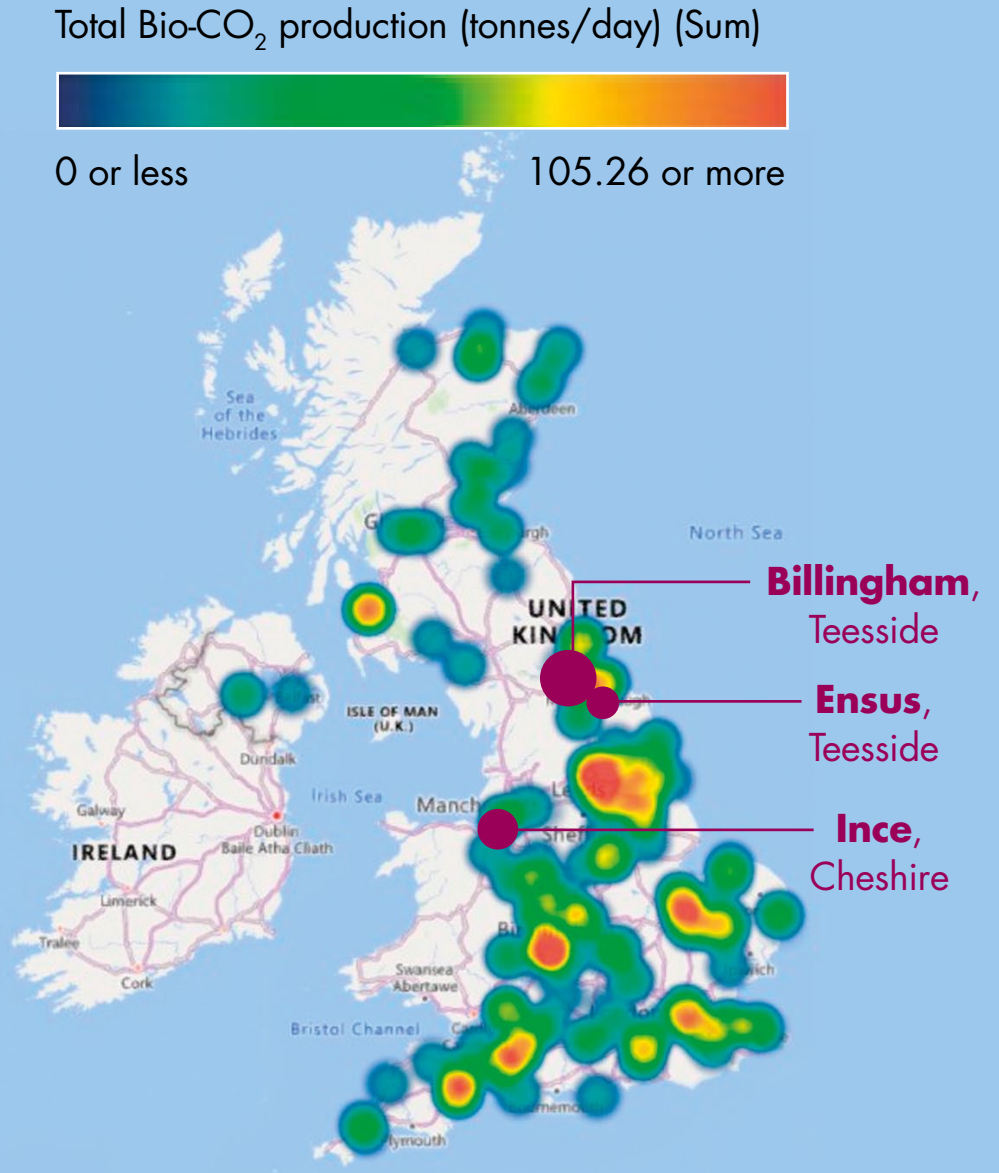
UK DISTRIBUTION

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

Biomethane plants are located across the UK, capable of providing local bio-CO_2 gas for local industry.

Co-location of industry and AD plants can save money on transportation costs and further reduce life cycle emissions.

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.



TRANSPORTATION

A typical gas transportation truck can hold around **20 tonnes** of compressed CO_2.

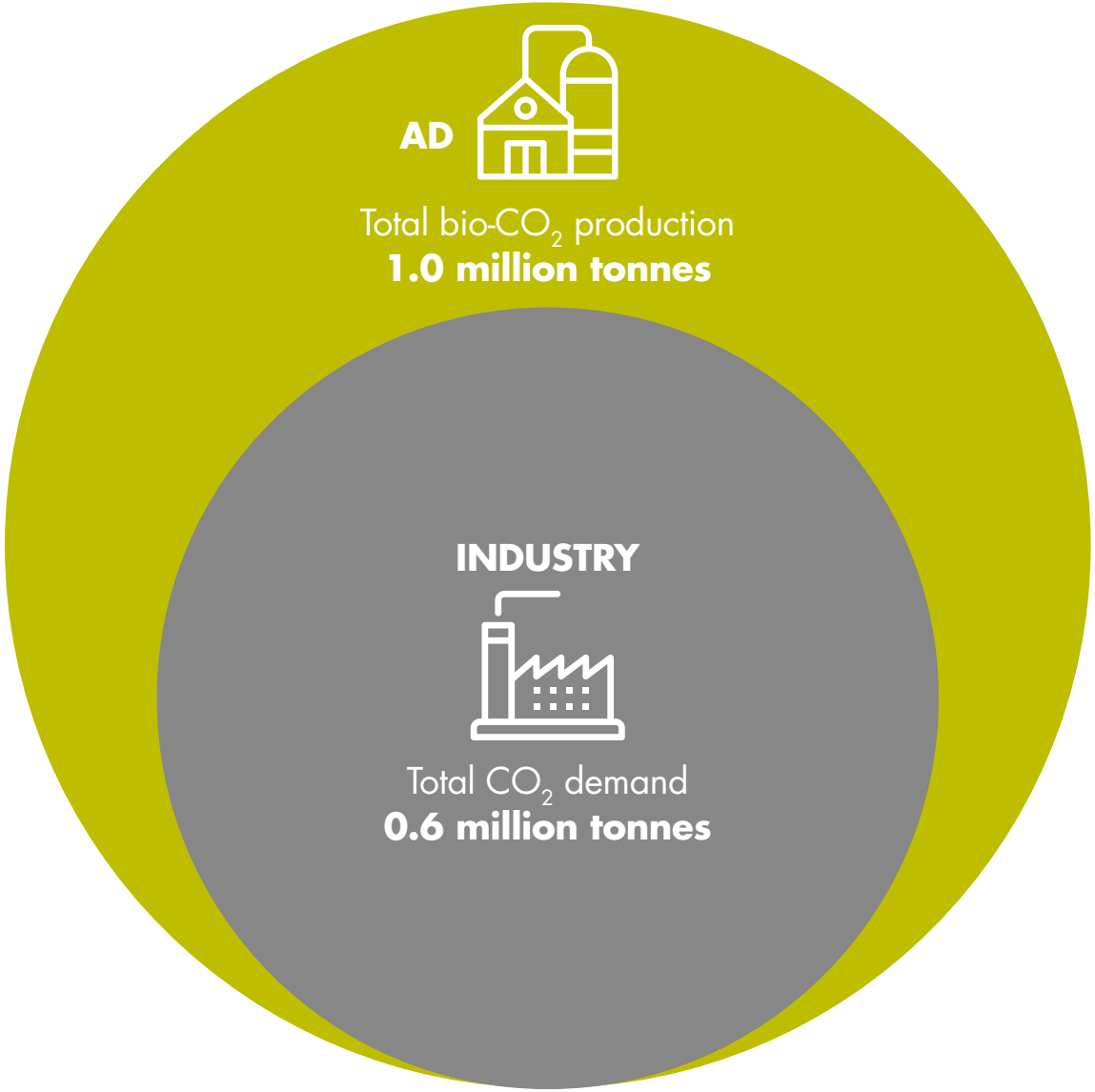
This map displays all locations within 25km of a biomethane plant capable of filling at least one truck per day.

In total, 78 biomethane plants could fill at least one truck per day.

BIO-CO_2 FROM AD

The UK currently has 133 biomethane plants producing almost double the CO_2 demand from industry.

The supply of bio-CO_2 from biomethane plants can reduce industries' dependence on the 2-3 major production sites – mitigating the risk of future CO_2 crises.



CURRENT BIO-CO_2 REGULATIONS

REGULATIONS AROUND BIO-CO_2

RPS 255

RPS 255 determines how the food- and industrial-grade CO_2 from AD must be treated during capture, storage, and usage to meet the required standards.

The Environmental Agency is currently considering whether to withdraw this RPS and incorporate the CO_2 regulations into the Biomethane Quality Protocol.

More information via: **RPS 255**

Operators must comply with these conditions for the CO_2 captured to be used in industries or the food and beverage sector.

- Applicable CO_2 production techniques include: filtering, washing, distillation, compressing, condensation, drying, and/or cooling
- Conditions for the operators
  - Have a contract of supply in place
  - Follow HSE guidance
  - Record the amount of CO_2 produced and stored on site
  - Achieve a CO_2 capture rate of at least 80%
  - Keep records of compliance with the RPS 255 for 2 years
  - Apply for a permit to capture, treat and store CO_2 within 18 months of the publication date of this RPS
  - Reduce/minimise the release of CO_2 into the atmosphere
  - Not store more than 150 tonnes of CO_2 at any one time
  - Not store CO_2 for longer than 6 months before use

STANDARDS AROUND BIO-CO_2: INDUSTRIAL-GRADE CO_2

Standards for industrial and food-grade carbon dioxide are typically dictated by the market. There are three market standards for industrial and food-grade CO_2.

BSI 4105:1990

Published in 1991, this standard provides guidance on packaging and identification specifications and sampling methods for industrial-grade CO_2. This specification helps manufacture high-quality liquid carbon dioxide.

BSI 4105:1990 specifies two types of carbon dioxide for industrial use

- Type 1 - for **industrial non-food applications**; for example, purging, inerting, and life raft inflation
- Type 2 - for **industrial food applications** such as beverages, gas packaging, food freezing and chilling

More information via: **BS 4105:1990: Specification for liquid carbon dioxide, industrial**

The quality of CO_2 is driven by the end-use market, with EIGA and ISBT standards now widely accepted to have superseded the BSI standard for CO_2 in the UK.

STANDARDS AROUND BIO-CO_2: FOOD-GRADE CO_2

EIGA Doc 70/17

EIGA standard on 'Carbon Dioxide Food and Beverages Grade, Source Qualification, Quality Standards and Verification' describes requirements for liquid CO_2 produced to be used in food and beverages.

It provides updated recommendations and guidance on ensuring the quality and purity of carbon dioxide for these applications.

Download the document via: **EIGA Doc 70/17**

ISBT BVG-00001

This guideline is currently recognised as the industry standard guideline for CO_2 used in beverages.

It offers guidelines for the proper handling, storage, transport, and testing of food-grade CO_2.

Bio-CO_2 sold as food-grade CO_2 in the UK must comply with the ISBT standards to be eligible.

More information via: **ISBT BVG-00001**

These standards look at the nature of the source of the CO_2. AD operators looking to capture CO_2 must implement a **suitable risk assessment for feedstock used in AD** to ensure that the product is safe to use in food and beverages.

POLICY AND THE FUTURE MARKET FOR BIO-CO_2

While gas customers may value AD's ability to produce local and renewable bio-CO_2, today's market fails to account for its GHG emission savings.

Under current policy fossil- and biogenic-derived CO_2 are treated the same.

Rewarding the climate benefit of utilising or storing bio-CO_2 could stimulate the rapid deployment of CCUS technology at AD plants – thus accelerating UK decarbonisation.

Valorising the environmental benefit of bio-CO_2 utilisation or storage

Certificates

Certificates could be used to verify the biogenic origin of CO_2 gas from AD and quantify its emissions savings when utilised or stored:

- **If utilised**, companies can purchase certificates to demonstrate direct emissions savings.
- **If stored**, third parties could purchase certificates to effectively remove their own emissions.

These certificates could feed into the **UK ETS**, allowing obligated parties to verify emissions savings.

UK Emissions Trading Scheme (UK ETS)

Set to become one of the UK's primary mechanisms to deliver Net Zero, the UK ETS employs a 'cap and trade' approach – a cap is placed on the total emissions permitted from a sector, and the relevant companies are left to trade emission allowances. Consequently, its costs to pollute.

CONCLUSION

1. Demand

Around 600,000 tonnes of CO_2 gas is **utilised** within industrial processes each year (e.g., food and beverage production).

+

Greenhouse gas removals (GGR) via bioenergy with carbon capture and **storage** (BECCS) will be essential in the delivery of Net Zero by 2050.

2. Capturing biogenic carbon

By treating organic feedstocks, anaerobic digestion (AD) captures biogenic carbon – i.e., carbon originating from the atmosphere.

Bio-CO_2 can be captured during the production of biomethane.

3. Current production

At present, the UK's 133 biomethane plants produce around **1 million tonnes of bio-CO_2 per year.** However, less than 10% is being captured, utilised or stored, due to two key barriers: **cost and perception.**

4. Valorising bio-CO_2

The value of bio-CO_2's ability to displace the use of fossil-CO_2 or deliver GHG removals must be accounted for by markets. **Bio-CO_2 certificates** could help accelerate CCUS deployment.

5. Full potential

At full potential, where all unavoidable organic wastes are recycled, the UK's AD industry could capture over **8.3 million tonnes of bio-CO_2 per year.**

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PENTAIR & FUTURE BIOGAS

Future Biogas is developing **Project Carbon Harvest** – a venture to design and operate the next generation of AD plants delivering BECCS.

Pentair is supplying the critical technology for AD plants to upgrade biogas into biomethane and capture the bio-CO_2 for utilisation or storage.

- Pentair Carbon Capture Technology will be installed across Future Biogas' portfolio of plants, both those currently operational and those in-development. By 2030, they aim to be capturing up to 400,000 tonnes of bio-CO_2 per year.
- All bio-CO_2 will be liquified on-site and transported to a carbon storage facility – several of which are being constructed around the UK, and each will have the capacity to store millions of CO_2 each year (e.g., Northern Lights, HyNet, Endurance). These facilities will inject the bio-CO_2 into sub-sea reservoirs, securely storing the carbon for >10,000 years.

This project is set to deliver the UK's first AD-derived GHG removals – essential for the delivery of Net Zero.

Subsidy-free AD

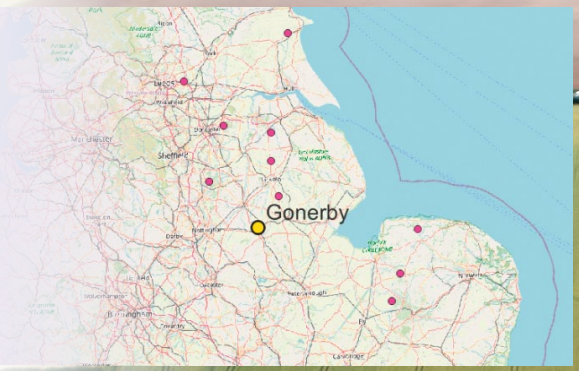
As the UK strives towards Net Zero, the value of biogenic CO_2 is skyrocketing. Many companies are seeking renewable sources of carbon for both current processes and the development of new products – and crucially, many companies will also need greenhouse gas removals (GGR) to offset their unavoidable emissions.

Future Biogas will generate high-value removal credits through the delivery of BECCS. By selling these credits to corporates, Future Biogas' new plants will not require Government subsidies.

PENTAIR & FUTURE BIOGAS

Gonerby Moor

Commission date: End of 2024
Feedstock (annual): 85,000 tonnes of sustainably-grown bioenergy crop
Biomethane (annual): 100 GWh
Bio-CO_2 (annual): 14,000 tonnes
CCS Technology: Pentair BioComplete



Gonerby Moor will be owned and operated by Future Biogas, and is on track to become:

The UK's first unsubsidised biomethane plant
and
The UK's first AD plant to target CO_2 sequestration

The plant will be primarily fed with maize, rye and barley – all of which will be grown under close working partnerships with farmers, transitioning to sustainable, low-carbon practices.

Over time, this will help build soil carbon, adding value to carbon certificates for both farmers and corporate off-takers.

WASTE-FREE CO_2 FOR FOOD INDUSTRY

Apsley Farms produce and capture waste-free CO_2 which is sold into the food and drink industry, achieving 97% sustainability criteria.

Built-in 2012, the flagship AD facility at Apsley Farms in Hampshire produces over 13MW of gas an hour, enough to supply around 9,500 homes per annum continuously.

In 2016, a new Pentair Carbon Capture Unit was added, taking Apsley Farms a further step forward on the carbon mitigation journey. This unit captures 30 tonnes of CO_2 per day, primarily sold into the food and drinks sector.

Apsley Farms take multiple actions to make sure that its CO_2 production practices meet the enhanced sustainability criteria. They are using advanced farming techniques to reduce CO_2 emissions during crop cultivation while optimising the storage and transport of crops to lower the carbon footprint of the raw materials.

NUTRIENT-ENHANCING FERTILISER USING CO_2

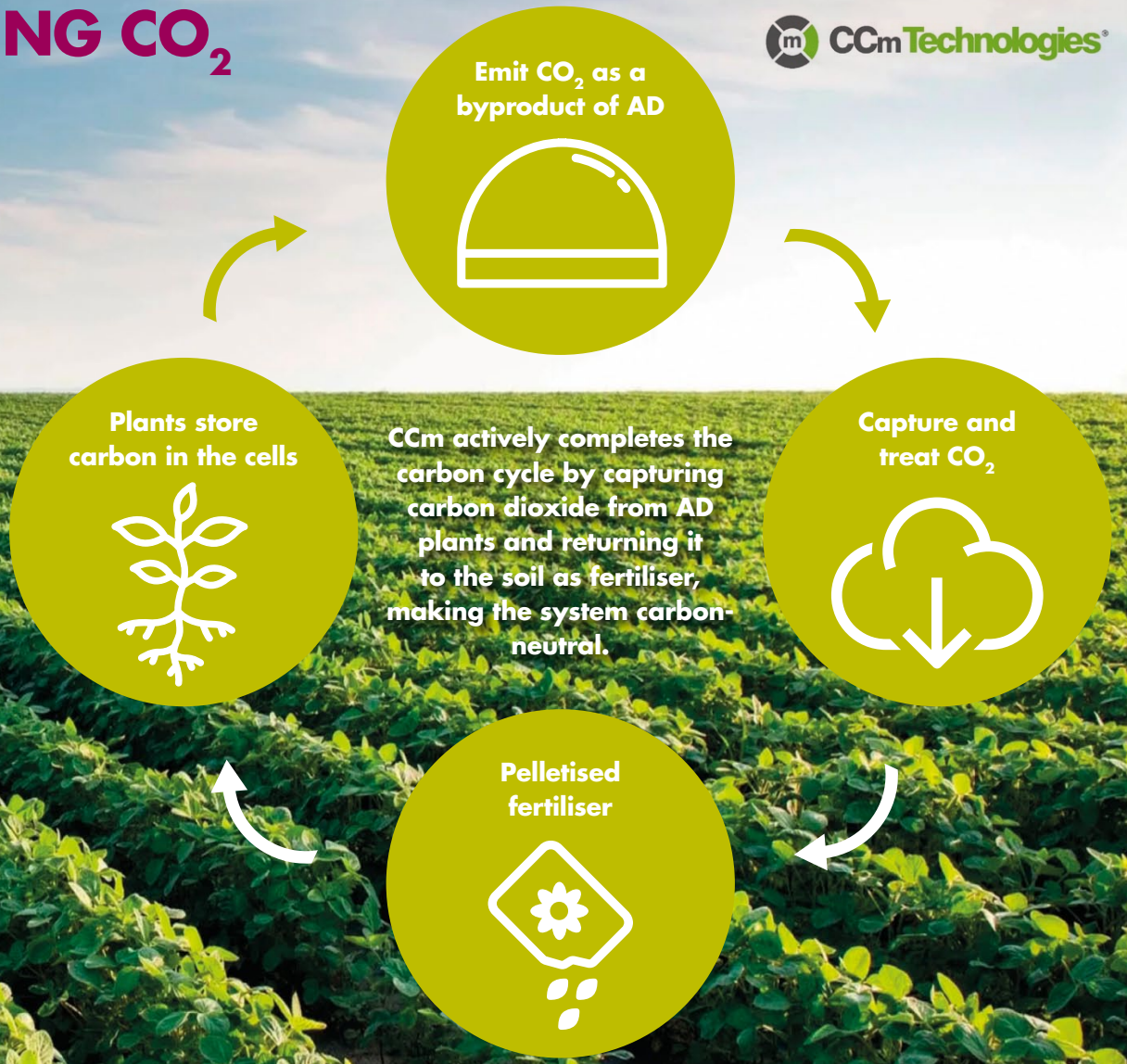
CCm Technologies

CCm Technologies combines captured CO_2 with digestate from AD, ammonia and phosphate from waste streams to produce an award-winning pelletised fertiliser that can increase the nutrient content in the soil and also provide Scope 3 emission reductions for corporates, such as PepsiCo

Why it is a game-changer?

- Emissions from manures and synthetic fertilisers are greater than aviation and shipping combined*
- Low-emission fertilisers are compatible with existing spreading technology, including on price
- 90% less carbon footprint than the mineral fertiliser
- Returns recalcitrant carbon back to the soil, balancing out the current CO_2 emissions

*Sources: Nature.com U Cambridge



PERMANENT STORAGE SOLUTION FOR CO_2

carbon8
a circular impact company

Carbon8's CO_2ntainer permanently captures and stores CO_2 by mineralising CO_2 within industrial residues to create carbon negative construction aggregates.

Carbon8 is seeking UK-based, CO_2 supply partners to permanently store captured CO_2 and unlock projects that can avoid industrial wastes being sent to landfill.

This technology has many benefits to industry:

- Efficient, permanent and secure storage of CO_2
- Transforming wastes into assets
- Enabling permanent carbon removal for biogenic CO_2

Capture & store **1000-4000 tonnes** of CO_2 a year

12,000 tonnes minimum waste treated per year

For more information, contact: **aaron.lyons@carbon8.co.uk**

Construction aggregates containing mineralised CO_2

The CO_2ntainer operating at a cement works in France

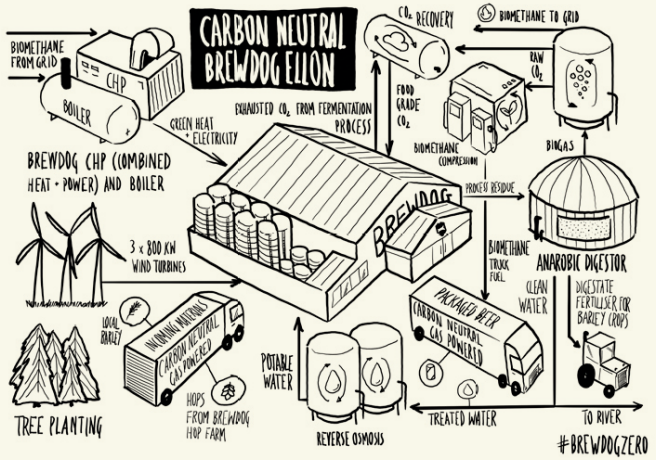
RECYCLING CO_2 TO HIT CARBON NEUTRALITY

Brewdog plans to integrate AD and CO_2 recovery and use in its supply chain in order to achieve net zero operations emissions at its Ellon plant by 2023.

The plant will recycle brewing residues to produce CO_2, biomethane, and water which it will then feed back into the production process.

By processing residues via AD, Brewdog aims to produce and use 4,500 tonnes of CO_2 a year.

In doing so, it secures a guaranteed supply of CO_2 while slashing process emissions and achieving carbon neutrality.



PENTAIR

Pentair specialises in biogas-to-biomethane upgrading and CO_2 recovery solutions for the agricultural and food processing sectors.

Our goal is to enable our customers to maximise their resources by upgrading their biogas into a higher methane-yielding, gas grid-ready biomethane.

We also provide the means to further refine this biomethane into a non-fossil-based biofuel used to decarbonise freight transportation.

Alongside Pentair Biogas Upgrading, we convert the CO_2 by-product into a viable commercial product with Pentair CO_2 Recovery Technology.

With 90 years of CO_2 capture & recovery expertise, let's work together to explore your biogas upgrading potential.

Insist on Pentair. Find out more at **biogas.pentair.com**

FUTURE BIOGAS

Future Biogas is one of the UK's largest producers of biomethane, injecting over 500 GWh of green gas into the grid each year.

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Founded in 2008, Future Biogas is a highly experienced developer and operator of AD plants across the UK, responsible for over £120m in biogas infrastructure. At present, it operates 12 large-scale AD plants, primarily located across the East and North-East of England.

With finance from our new majority owner 3i Infrastructure (an FTSE-250 listed investment firm), Future Biogas is now developing a series of new unsubsidised biomethane plants with carbon capture technology – the first of which is already in construction.

Find out more at **futurebiogas.com**

FIND OUT MORE

If you are interested in finding out more about ADBA, please contact
T: +44 (0)20 3176 0503 E: **enquiries@adbioresources.org**

ADBA | Anaerobic Digestion and Bioresources Association | **THE ENERGY BEHIND THE AD REVOLUTION**

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