THE WORLD'S CHEAPEST CLEANER

WHY CARBON CAPTURE FROM BIOGAS UPGRADING MAKES SENSE

ADBA

FOREWORD GREEN GAS IS CRITICAL TO OUR ENERGY AND CLIMATE SECURITY - AND ECONOMIC SUCCESS

Green gas has made great strides in the last year in being recognised as an indispensable part of our clean, sustainable future. In particular, the National Energy System Operator (NESO) has set out how crucial biomethane will be in achieving net zero carbon emissions, thanks to its flexibility as an easily storable energy source that can back up the whole system when there are not enough other sources to ensure energy security. Green gas can keep the lights on during long, dark and cold winter nights. Green gas is renewable, reliable and ready.

However, NESO did not model one of the most compelling benefits of the biogas to biomethane process, which is why this report from our policy lead Dr Gareth Mottram is so necessary. The biogas process can capture carbon dioxide (CO_2) more cheaply and more assuredly than any other technology. If this CO_2, known as bioCO_2, is then used in the food and drinks industry – such as for fizzy drinks – it replaces man-made and global warming CO_2. If it is stored underground – in an old North Sea gas field for example – then the whole process removes greenhouse gases from the atmosphere.

By removing CO_2 from the atmosphere with a proven, tried and tested technology, historic polluting technologies that are more difficult to replace can continue for longer, giving British industry a key breathing space and making enormous economic savings on the journey to net zero. Our report last year[1] showed that these savings amount to £298 billion or more than £400 for each UK household each year.

This report sets out the latest evidence in light of the greenhouse gas removals (GGR) review[2] led by Dr Alan Whitehead, now Lord Whitehead and a newly appointed minister at the Department of Energy Security and Net Zero (DESNZ). In the final section, we also provide a summary of the key "asks" that ADBA is setting out to speed up growth and the resulting creation of jobs. Biogas could employ 60,000 people across the economy by 2050, ensuring many jobs in key parts of the gas grid.

I would like to thank our partners in the Green Gas Task Force (GGTF) and notably the gas networks for their key support in making our case this year and sponsoring GGTF reports on the exciting potential of green gas. Along with the GMB trade union, representing the skilled engineers in the gas sector, we are now a powerful coalition working for green gas.

Most important of all, we have a strong and incontrovertible case for action. Gas has for far too long been only seen as part of the factors causing climate change. Some people seem to think that anything that burns is bad and needs to stop. This report proves beyond a shadow of doubt that they are wrong. We must not throw out green gas just because of the problems caused by fossil gas. Green gas is a home-grown and sustainable part of our future. Green gas is not part of the climate change problem; it is a critical part of the solution.

Chris Huhne, ADBA Chair

1 The-role-of-Green-Gas-in-Net-Zero-report-Dec-2024.pdf

2 www.gov.uk/government/publications/greenhouse-gas-removals-ggrs-independent-review

EXECUTIVE SUMMARY

1) The biogas process (upgrading biogas to biomethane and carbon dioxide) is the cheapest way of engineering the removal of greenhouse gases from the atmosphere, sharply cutting the cost of the transition to a less polluted world.

2) Biogas purification is a simple, proven technology already working at scale, in contrast to every other technology for carbon capture - including capture from the exhausts of power stations (BECCS) and capture from the air (DACCS)).

3) The benefits of low-cost carbon capture through the biogas process have been increasingly recognised by policymakers, but the National Energy System Operator (NESO) recognises that it has still to model its benefits in its projections for net zero. This delay should not hold up implementation.

4) The removal of greenhouse gases through the biogas process can meet as much as a quarter of the UK government's projected need for carbon removals in 2050 – about 18m tonnes of CO_2 – and the savings can begin right now by buying more time for the transition.

5) Greenhouse gases can be removed and stored through the biogas process for as little as £54 per tonne and up to £123 per tonne. This is around 16% the cost of Direct Air Capture, a touted alternative.

6) No other technology for the removal of greenhouse gases is as cheap because other techniques must capture a much large volume of emissions to get the same volume of CO_2.

7) The capture and storage of CO_2 from biomass is a permanent removal of atmospheric CO_2.

8) The trucking of liquefied CO_2 – the so-called "virtual pipeline" - is also a commercially proven concept in the UK and can be accomplished economically as a way of permanently storing CO_2 in safe places like saline aquifers and former North Sea oil and gas fields.

9) Backing biogas and its low-cost greenhouse gas capture would deliver enormous benefits to the whole energy system by lowering the costs of transition.

10) Once both the system benefits and the low-cost carbon capture benefits of the biogas process are taken into account, the effective cost of biomethane can fall to £48 per MWh.

11) By capturing greenhouse gases, the biogas process allows hard-to-decarbonise sectors – aircraft, heavy goods vehicles, shipping, chemicals industry - to operate for longer, protecting net zero targets while reducing the economic cost of the transition.

THREE THINGS TO REMEMBER ABOUT GREEN GAS

1. **VALUE FOR MONEY** Green gas is the cheapest engineered way to capture the greenhouse gas CO_2, and reverse global warming.

2. **READINESS** Green gas technology is tried, tested and proven. It is a technology that is home-grown and guarantees energy security.

3. **RELIABILITY** Green gas is storable and available when other renewables do not work. It is the key back-up for a clean energy system.

THE WORLD'S CHEAPEST CLEANER

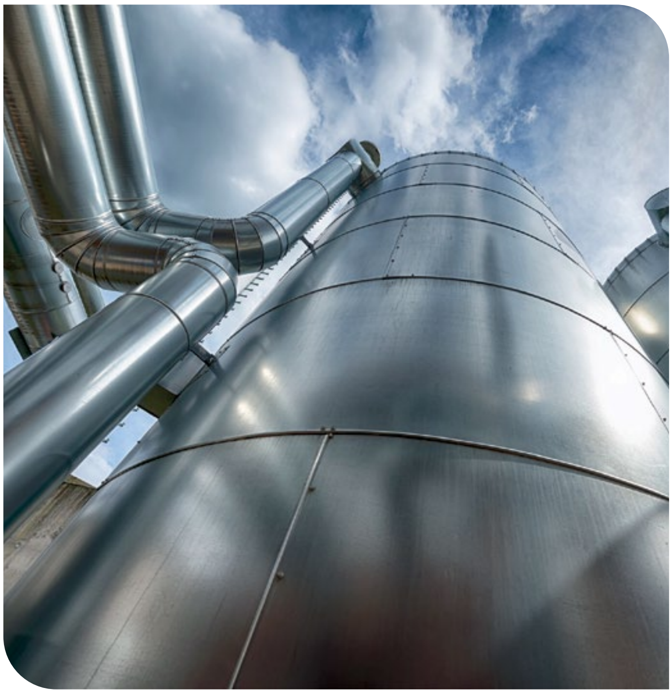
WHY CARBON CAPTURE FROM BIOGAS UPGRADING MAKES SENSE

Biogas Can Remove Greenhouse Gas

Biogas is produced from any organic matter such as food waste, manure or energy crops, which is then broken down by microorganisms in the absence of oxygen (hence "anaerobic digestion (AD)"). The raw biogas typically contains about 50–65% methane (CH_4), 35–45% carbon dioxide (CO_2) and trace impurities. To create biomethane, the gas undergoes upgrading processes such as membrane separation to remove CO_2 and other contaminants[3].

Some AD plants have found markets for this bioCO_2 in the food and fizzy drinks sector, but others just vent it back into the atmosphere. This is a wasted opportunity given the efforts that the government is putting into removing greenhouse gases from the atmosphere and from industrial processes. Removing greenhouse gases is thought to be essential to stop over-shooting climate targets and allow some carbon intensive activities to continue where no carbon neutral alternative exists. Greenhouse gas removals (GGR) is an increasingly important part of the work of DESNZ.

The UK government estimates that the final demand for GGR to offset hard to abate sectors in 2050 will be around 81Mt CO_2/year[4] and has identified 78Gt of storage capacity. BioCO_2 from biomethane upgrading could account for 17-22% of this GGR demand. While the UK's maximum output of biomethane depends on the amount of organic matter that can be sustainably processed, an authoritative recent study put this total at 120TWh of biomethane[5]: the resulting bioCO_2 would therefore be around 17-18Mt.



The primary method projected for carbon storage in the UK is the use of pipelines fed with CO_2 captured from industrial cluster point sources. These point sources were initially expected to be heavy industry, steel works and power generation. This presents a problem if the CO_2 has to be collected from many smaller point sources in the form of AD plants. But this is a false limiting factor: virtual pipelines (non-pipeline transport) provide a viable, scalable and proven alternative. This option has been mooted in a government consultation, but the thinking in Whitehall seems to be that this is a "nice to have" at some point in the future rather than something that should be done immediately – or at least quickly.

3 The production of biomethane from raw biogas generates roughly 1 kg of CH_4 for every 1.5–2 kg of CO_2, reflecting the typical composition of the feed gas and the separation efficiency during upgrading. One kilogram of methane (CH_4) contains about 55.5 megajoules (MJ), equivalent to roughly 15.4 kilowatt-hours (kWh) of energy. On an industrial scale this means that around 7MWh of biomethane is produced for every 1tonne of bioCO_2 separated and liquified.

4 www.gov.uk/government/publications/net-zero-strategy

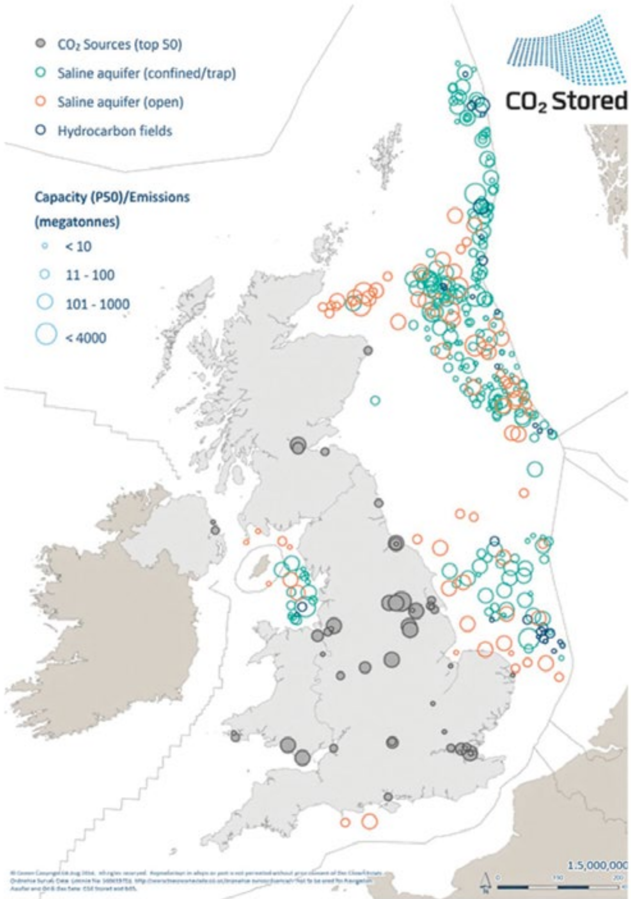
5 https://greengastaskforce.co.uk/wp-content/uploads/2025/09/GGT-Unlocking-the-Potential-of-Biomethane.pdf

ENGINEERED GREENHOUSE GAS REMOVALS

Storage

The UK has the opportunity to become a leader in the deployment of GGR. This is because the UK has the advantage of appropriate geological structures for gas storage under the North Sea, providing over 70Gt of storage capacity[6].

First, retired oil and gas fields are on hand with natural stone seals that kept gas in place for millions of years: they can be repurposed. Secondly, there is a lot of potential in saline aquifers as well. If the full capacity is confirmed, greenhouse gases can be put into storage there for around 800 years at the projected rate of capture. If only old hydrocarbon fields are usable, then this comes down to a still impressive 200+ years.



CO_2 Storage Capacity Estimation.

(CO2 Stored © BGS/UKRI)

Removal Methods

There are several key technologies highlighted by the UK government in its review of greenhouse gas removals. For example, nature-based solutions (tree planting, promotion of wetlands and so on) are often the cheapest form of removal but are sometimes criticised for not being genuinely additional to other efforts. In this report, we focus on engineered removals as these are the most comparable to AD Energy Carbon Capture and Storage (ADECCS) in terms of scale and permanence.

The key technologies are Power Bioenergy with carbon capture and storage (PowerBECCS), focused on wood, straw and mixed Energy from Waste (EfW) combustion and Direct Air Carbon Capture and Storage (DACCS). The energy requirements and cost of these are highly varied and have very different maximum potential.

PowerBECCS

PowerBECCS is limited by the availability of sustainable biomass to feed into thermal power plants fitted with flue gas carbon capture and storage (CCS). EfW mixed waste should not be a part of this consideration, as this has been identified in the circular economy strategy as a sunset system. The costs for this use of mixed waste EfW +CCS are going to resemble PowerBECCS but be limited to a fraction of the output based on the organic content of the input. Furthermore, AD has been designated as the preferred recovery method for domestic organic wastes.

Waste wood will remain available from the construction sector[7]. Some 3.9Mt is commonly produced in the UK, so there is potential for just under 2Mt of waste wood CO_2 capture, as wood is normally around 50% carbon. If imported wood can be sourced sustainably, this number gets a lot higher but is very uncertain given the disagreements on the sustainability metrics. DRAX currently consumes between 5-7Mt of wood, providing potential for another 2-3Mt of carbon capture from this.

6 www.co2stored.co.uk/home/about_faq

7 www.commercialwastequotes.co.uk/blog/uk-waste-data-insights/

Technology	Cost/tonne high	Cost/tonne low	Potential scale
PowerBECCS[8] (woody)	£334	£223	5Mt[9] (CCC 25MT[10]) (Gvt. 58Mt)
DACCS[10,7]	£739	£169	uncapped
ADECCS	£80	£20	18Mt

Cost Comparison of Engineered CO_2 Removal Pathways

It is unclear how much larger the potential of this technology is, although if enough sustainable wood can be found then clearly the potential is higher. Indeed, the government's PowerBECCS forecasts indicate it can find over 100Mt of sustainable wood, though it seems likely this includes feedstocks like chicken litter that like EfW are better treated through AD. The potential domestic and recognised available sustainable wood for PowerBECCS will likely be a constraining factor.

PowerBECCS uses the same post-combustion CCS approach as gas turbines, but the flue gas from burning biomass is dirtier. Biomass combustion produces higher levels of tar, soot, ash, and other contaminants, which make the CO_2 capture process more complex. These impurities can foul equipment, reduce capture efficiency, and require more extensive cleaning and gas-treatment steps before CO_2 can be captured and compressed.

DACCS

There is no theoretical cap on the amount of carbon direct air capture (DAC) can extract from the atmosphere (unlike biomass and AD), but it is very expensive. DAC is essentially human engineering trying to emulate photosynthesis. The process is extremely energy intensive. One report says that "current energy requirements for Climeworks' DAC process are 500 kWh/tCO_2 electric energy and 2,000 kWh/tCO_2 thermal energy"[11].

Compared to biomethane, DAC is net negative on energy by 3MWh (of thermal energy) as opposed to positive by 7MWh from the ADECCS. A recent piece in the Financial Times quoted Bloomberg New Energy Finance research; *"...NEF has shown that costs for the industry as a whole are even higher, with the average cost of capture at $900 (£739) per tonne and likely to fall to $487 (£398) per tonne by the end of the decade."* These values will be closely linked to the cost of renewable energy.

As with many electrolytic hydrogen projects, DAC projects will be capital intensive and consequently required to operate as often as possible to give them the best chance of earning a financial return. If they must pause and only operate when electricity is very cheap (for example in the middle of the night), then they are likely to have erratic and longer payback times and lower rates of return. The high cost of DAC systems is therefore a key obstacle to their deployment. Ironically the Transport & Storage element that is needed to make DAC into DACCS is the cheap part of the system, exactly the reverse of ADECCS.

ADECCS

The ADECCS solution however is both cheaper and more resilient than both PowerBECCS and DACCS, being less dependent on single point sources as well as needing less energy to operate. The current consensus cost for AD CO_2 separation is under £80/tonne, less than half the (optimistic) estimate of the cost of PowerBECCS and DACCS in 2035.

As previously outlined, biomethane has a likely ceiling of 18Mt per year of CO_2 capture based on sustainable domestic feedstocks in the UK. The CO_2 separation technologies commonly deployed produce both the best methane for the gas grid but also the best CO_2 if an alternative use in industry emerges as the preferred pathway to storage. In this way ADECCS offers systems-wide benefits.

8 https://assets.publishing.service.gov.uk/media/68f8d27a0794bb80118bb764/independent-review-of-ggr.pdf

9 This assumes only domestic waste wood and the continued operation of DRAX with the caveat that its current feedstocks are considered sustainable.

10 www.theccc.org.uk/publication/the-seventh-carbon-budget

11 https://publications.ieaghg.org/technicalreports/2021-04%20Techno-economic%20Performance%2C%20Opportunities%2C%20and%20Challenges%20of%20NETs.pdf

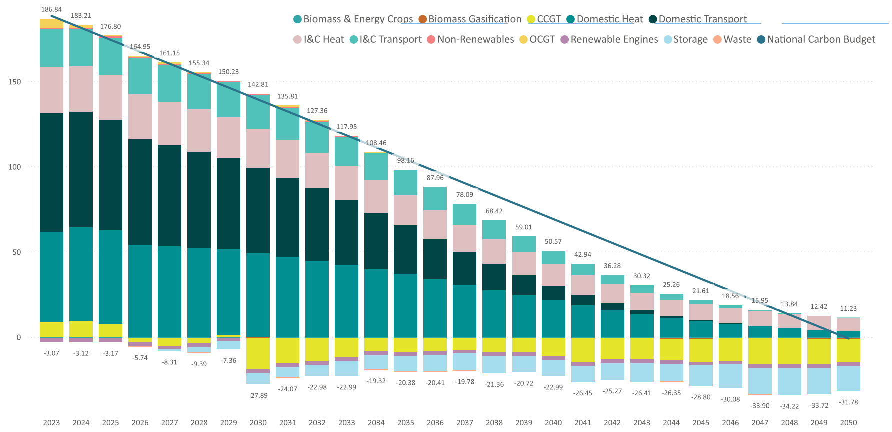


Figure 1 Carbon Distribution in 2050 with No Biomethane

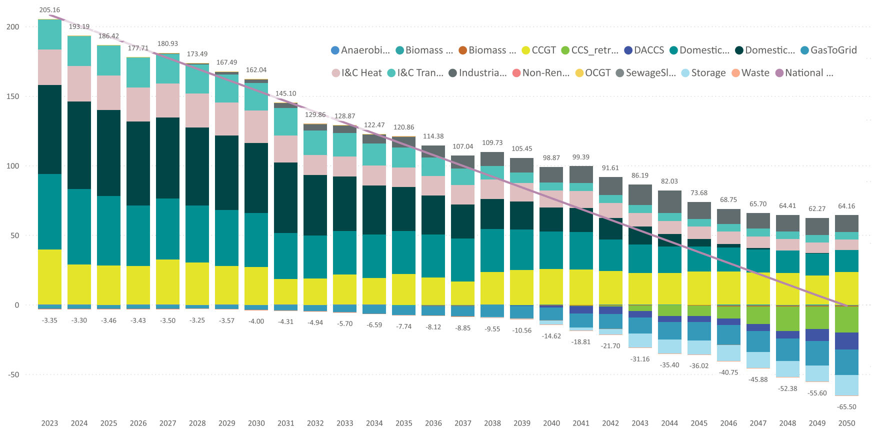


Figure 2 Carbon Distribution in 2050 With 100TWh of Biomethane

Last year, ADBA and Business Modelling Applications (BMA) modelled the impact of biomethane CO_2 separation on the UK economy and net zero journey, using a computer model of the whole energy system currently being used by both DESNZ and NESO. This analysis found that there were significant advantages to the inclusion of ADECCS compared to the Future Energy Scenarios (FES) in 2024. This change leads to around double the carbon removals seen in the FES. This is clearly shown by comparing the negative emissions – the bars below the zero line – in the two figures: the first figure gives the NESO 2024 projection, and the second figure shows the doubling of removals when biomethane is added to the energy system.

The increase in removals allows much more flexibility in how and when fossil carbon is removed from the UK economy over the next 25 years. Hard to replace technologies could continue for longer because their pollution is offset by green gas removals.

Carbon Transportation

The Biomethane Industrial Partnership (BIP)[12] identifies the logistics of bioCO_2 and the geographically distributed nature of the AD plants as a potential bottle neck. Yet the use of a virtual pipeline is a proven concept.

Hub and spoke injection has been pioneered by SGN. In this scenario, the biomethane plant is located close to main roads and the necessary source of organic feedstock, rather than on the gas grid. The gas produced is then compressed and trucked to a hub where it can be injected into the gas grid. These hubs can take biomethane from multiple sites, (the spokes). It is an option for both the biomethane getting into the grid and for trucking bioCO_2 into storage.

The UK already has trucks capable of transporting CO_2 as this is a common commodity for industry and the food and drink sector. Indeed, one recently commissioned biomethane plant uses this technology to truck both its biomethane (to a grid injection point) and its liquefied bioCO_2 (to its food and drink sector customers).

12 https://bip-europe.eu/wp-content/uploads/2024/04/TF4.1_BioCO2-from-biomethane-production_final-report.pdf

A recent DESNZ consultation on the potential for non-pipeline transport of CO_2 for CCS estimated the costs of transport at £100-345/tonne[13]. This figure is incorrect. It comes from a Welsh government paper, which included the cost of capturing CO_2 from industrial sources and not solely the cost of trucking. The quoted figure is for transport by ship (i.e. £5-20 more expensive than by pipeline).

In fact, none of the transport costs of CO_2 exceed £50/tonne, which should be compared the estimates of pipelines costing £20/tonne. Because of the low cost per mile of trucking, under £1/mile, and under £5 /tonne cost of liquefaction we believe[14,15] that it is likely that the surface transport costs will be closer to the lower end of the range at £25-30/tonne. While the costs of a virtual pipeline are higher than a real pipeline but are more than cancelled out by the lower costs of capturing bioCO_2 in the AD process.

Correcting this wrong assumption enhances the value and competitive advantage of ADECCS. Assuming that all the bioCO_2 coming from biomethane upgraders is captured and moved by truck (a worst-case scenario), the cost of capture and storage is still under £2bn per year (£80-120/tonne captured, trucked and stored). This analysis shows that capturing, transporting and storing upgraded bioCO_2 from AD costs about the same as the low-end estimate for PowerBECCS capture, considering only domestic woody waste and existing sources.

SCENARIO	TOTAL COST (£)
Capture only	1,080m
Capture + Transportation & Storage (Low)	1,440m
Capture + Transportation & Storage (High)	1,620m

Costs of CO_2 Capture Versus Full CCS Pathways

The cost and availability case is compelling and has been confirmed by a recent study from the Green Gas Task Force (GGTF). Based on best estimates within the industry, it should be possible for trucked bioCO_2 to be put into long term geological storage for £54-123/tonne[16]. A carbon price of £120 on the UK Emissions Trading Scheme (ETS) would make the low end of this estimate for ADECCS projects viable from the carbon and gas value, if there were support from the carbon price in the ETS.

THE UK'S CARBON CROSSROADS

Leader or laggard?

The volumes of bioCO_2 additional to the existing market are large. The French biomethane industry is actively participating in the development of carbon storage infrastructure to address some of the potential bottlenecks[17,18]. The need to deal with distributed sources of bioCO_2 is clearly recognised from the start. This is in contrast to the UK, where policy planning has focused just on concentrated industrial clusters for fossil emission abatement.

France produced around 14TWh per year of biomethane as of March 2025 with another 15TWh that could be commissioned by 2028. This would likely be over triple the UK deployment. These are dominated by agricultural feedstocks as a combination of wastes and residues and intentional feedstocks like rotational and cover crops. The CO_2 collection potential of the French biomethane network is already 2MT/year and could be greater than 4Mt/year by 2028. The French gas grid operator, GRDF, is actively engaged in planning to collect and store this bioCO_2.

France is notable as having the highest fraction of low carbon electricity generation – due to its long-standing commitment to nuclear – but it is nevertheless promoting biomethane with enthusiasm, recognising it can decarbonise hard-to-abate sectors, such as farming, transport, chemicals and heavy industry. It promotes the circular economy and enhances energy security and meets regulatory requirements under EU directives. This should be a wake-up call for the UK government as British companies could face a competitive disadvantage with the advent of EU carbon border adjustment mechanisms.

13 www.gov.wales/carbon-capture-utilisation-and-storage-network-wales-report

14 www.rha.uk.net/Portals/0/Membership/Annual%20Cost%20and%20Pay%20Surveys/Cost-Tables-2024.pdf

15 https://zeroemissionsplatform.eu/publication/the-costs-of-co2-transport

16 https://shorturl.at/n5aqd

17 www.offshore-energy.biz/frances-co2-transport-liquefaction-and-export-infrastructure-project-moves-to-pre-feed-stage

18 https://cdn.catf.us/wp-content/uploads/2025/03/06113905/ccs-fact-sheet-france.pdf

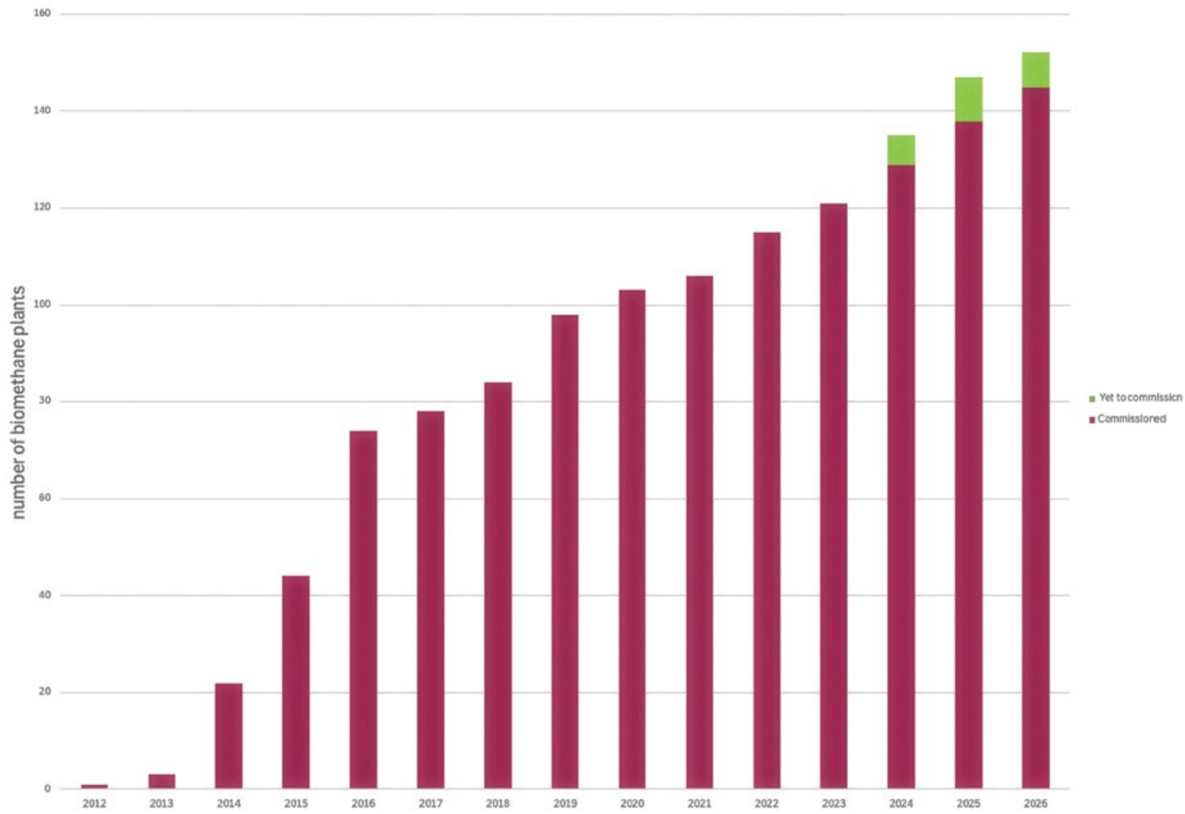


Figure 3 New Biomethane Plants by Commissioning Year

In Denmark, the INEOS Greensand carbon storage project is commissioning with bioCO_2 from the Danish biomethane sector. INEOS says: *"The CO_2 in the first phase of Greensand Future will be captured and liquified at Danish biomethane production plants, transported to the port of Esbjerg, and then shipped by Royal Wagenborg to the Nini field in the Danish North Sea for safe and permanent storage"*[20]. This is driven by scale: the volumes of bioCO_2 from biomethane upgrading available and the low cost of the bioCO_2 enabling cost effective trials and commissioning. In the future, INEOS Greensand will also use CO_2 from fossil sources but is likely to continue to store large amounts of bioCO_2 from the biomethane sector for exactly these cost and availability reasons, as well as the ability to generate CO_2 emission allowances under the EU ETS.

The UK fares badly by comparison. The rate of deployment of new biomethane in the UK is now around 2% of installed capacity per year. The UK has fallen so far behind France that it has around half of the French capacity. By contrast, after the launch of the Renewable Heat Incentive (RHI) in 2011, the UK biomethane sector grew on average by more than 20% a year.

The RHI was the first mechanism globally to promote biomethane injection into a gas grid. Since its closure to new projects in 2021 and its rushed replacement with the Green Gas Support Scheme (GGSS), the pace of capacity growth has been disappointingly slow. This is in part because of the limitations of the GGSS and the need to adapt to the new rules. There are more than 14 new plants of no less than 60GWh each being developed. However, they are slow in being delivered, and likely to cluster around the end of the scheme, which has already been extended until 2028. This limits the future potential of the scheme to drive AD to support carbon removals.

The debate around a future support mechanism often involves talking about the how much of the burden of support can be transferred to the UK ETS. Whilst this is the correct place to support carbon removals or abatement, it is not appropriate to move from only supporting the energy to using only carbon to support the energy, particularly in view of the system benefits that are now widely recognised.

20 www.ineos.com/news/shared-news/ineos-led-greensand-to-become-the-first-full-scale-co2-storage-facility-in-eu-to-help-mitigate-climate-change/

We should do more with biomethane derived CO_2. It is not a magic bullet, but it does offer a threefold solution: renewable energy, atmospheric carbon removals and displacement of synthetic fertilisers. Each tonne of synthetic nitrogen fertiliser produces between 2-5 tonnes of fossil CO_2. With the anticipated advent of the carbon border adjustment mechanism (CBAM) this could add up to £250 to the cost of these fertilisers on import. Biomethane produces a stream of nitrogen suitable for use as fertiliser and can therefore deliver not only the carbon removals from upgrading but also replace the imported carbon emissions from synthetic fertilisers. The UK imports around 1MTonnes of nitrogen fertiliser per year meaning up to 5Mtonnes can be saved by replacing this with the organic nutrient streams from AD.

Economic Opportunities of ADECCS and AI Data Centres

The new challenge to the energy system is the enormous electricity demand from the data centres needed for artificial intelligence (AI). There are proposals for around 100 new UK based datacentres before 2030[21]. These will all need to have a significant power supply both for operation and for cooling. Typically, each one would need a round 400-500GWh of electrical power per year. That is not practical to supply quickly by electricity cable to many of these sites, as they would require electricity grid reinforcement that will take many years to achieve at very significant costs. For example, operators have been quoted periods of 15 years to connect to the electricity grid. Any such delay is likely to impose significant competitive disadvantage on the UK economy if its rivals can access what is expected to be a key productivity-boosting technology. It is, though, plausible to deliver a gas connection to a data centre, and for it to use combined cycle gas turbines (CCGT) or fuel cells on site to produce the required electricity.

Unlike the electricity grid, the gas grid has fewer constraints (though not quite as geographically extensive). As a launch fuel, biomethane can offer an attractive solution to these centres. Moreover, generating electricity from an on-site biomethane supply is likely to be cheaper than purchasing it from the grid (not least due to system costs). If they were also able to claim biomethane against any obligations under the UK ETS, the proposition would be even more attractive (this is currently not possible as mistakenly the UK scheme, unlike the EU scheme, treats biomethane as if it were fossil gas). Data centres could put together a consortium to build five or six new biomethane plants, each feeding into the gas grid anywhere in the UK, and they would have assured green power by 2030[22].

Technology	Energy Source	Efficiency	Carbon Emissions (KG CO_2/KWh)	Total Emissions For 600 GWh (KG CO_2)	Total Emissions (Tonnes CO_2)
CHP Units	Natural Gas	40%	0.46	276,000,000	276,000
CHP Units	Natural Gas + CCS	40%	0.046	27,600,000	27.6
CHP Units	Biomethane	40%	0.0	0	0
CHP Units	Biomethane + CCS	40%	0.0	0	-275,973
CCGT	Natural Gas	55%	0.185	111,000,000	111,000
CCGT	Natural Gas + CCS	55%	0.0185	11,100,000	11.1
CCGT	Biomethane	55%	0.0	0	0
CCGT	Biomethane + CCS	55%	0.0	0	-110,989
Gas Fuel Cells	Natural Gas	50%	0.185	111,000,000	111,000
Gas Fuel Cells	Natural Gas + CCS	50%	0.0185	11,100,000	11.1
Gas Fuel Cells	Biomethane	50%	0.0	0	0
Gas Fuel Cells	Biomethane + CCS	50%	0.0	0	-110,989

Emissions Performance of Gas Technologies

21 www.theiet.org/media/press-releases/press-releases-2025/press-releases-2025-july-september/18-august-2025-iet-responds-to-plans-for-100-new-data-centres-across-uk

22 Typically, a biomethane plant takes between three and four years to build, depending principally on the speed of the planning process.

Data centre operation can significantly impact carbon emissions depending on the chosen energy source and technology. The use of biomethane **causes no net CO_2 emissions**, while various natural gas technologies produce substantial emissions (although these can be offset using CCS technologies). The cost of carbon emissions from use of natural gas would be over £6m/year. Using ADECCS could push these figures significantly negative. In the short-term, supporting biomethane build out to supply these data centres makes sense. In the longer run, they would ideally be able to access enough renewable or zero carbon electricity to operate and free up the biomethane capacity for other applications such as industrial heat. Choosing cleaner energy sources and technologies not only lowers carbon impact but also aligns with sustainability goals.

If data centres were to be powered by electricity generators fuelled by biomethane, there would potentially be a further benefit to the government if the CO_2 were captured and stored. The negative emissions could be of the order of 86,000 tonnes a year, which would provide some relief on the need to move faster on hard-to-abate technologies.

What if We Use the BioCO_2?

A further alternative is for biomethane and its associated bioCO_2 to be used in the production of sustainable aviation fuel. The UK Sustainable Aviation Fuel (SAF) mandate has a 0.2% Power-to-Liquid (PtL) target from 2028. This requires converting energy into hydrogen and fusing it with CO_2 to produce a carbon neutral SAF. This mostly happens through the well understood but very energy intensive process known as the Fischer-Tropsch (F-T) reaction. Fundamentally, the energy requirements for this are very high, both in the separation of the hydrogen and the F-T process (~28MWh/tonne of SAF for F-T and a further 6MWh/tonne for the hydrogen).

Consequently, the estimated cost of PtL SAF in 2040 is around £8,000/tonne, roughly 10 times that of conventional aviation fuel and three times that of used cooking oil (UCO) based SAF. To keep this price down and have any chance of a commercial profit, the CO_2 involved will need to be as cheap as possible whilst qualifying as net zero. This means that the bioCO_2 from biomethane production should be extremely attractive to SAF manufacturers.

The production of the PtL SAF at a retail value of £8000/tonne needs £2-5,000 of wholesale electricity in the UK, so there is little left to pay for two tonnes of expensively produced CO_2 from direct air capture (DAC). However, a producer could purchase bioCO_2 from biomethane upgrading and save substantial sums of money compared with either paying for carbon market credits or for expensive direct air capture.

SYSTEMS-WIDE ECONOMIC BENEFITS

The Value of AD

It is important when comparing different technologies to look at their real costs. Most renewable and low carbon technologies are discussed in terms of their 2012 prices, as these are used in the Government's contracts for difference (CfD) renewables' auctions and for nuclear. On this basis the contract for the new nuclear plant at Hinkley Point is set in 2012 prices at £89.50 per MWh, which converts to a current price of £124.70 per MWh. For comparison, biomethane projects come in at a range of between £75 and £100 per MWh in the UK at present, but this is the cost of the gas before it is used to generate electricity (which involves heat losses). Using ADBA/BMA modelling, we assume a cost for electricity from biomethane of £133 per MWh (electrical). ADBA has set out the comparable figures for other technologies and biomethane – in both 2012 and in current prices - in the following table.

Technology	Price/MWh (CfD 2012 price)	Adjusted price 2025 £
Wind (offshore)	£58.87	£82
Wind (onshore)	£50.90	£70.90
Solar	£50.07	£69.80
Nuclear	£89.50	£124.70
Biomethane to Electricity	N/A	£133[23]

Cost Comparison per MWh of Different Low Carbon Power

23 https://adbioresources.org/wp-content/uploads/2024/12/The-role-of-Green-Gas-in-Net-Zero-report-Dec-2024.pdf (£77/MWh/58% efficiency for CCGT)

Technology	Levelised Costs	Additional Systems Costs	Enhanced Levelised Costs (Total)	Price with 2025 CfD strike price
Onshore wind	£52	£72	£124	£142.90
Solar	£52	£65	£118	£134
Offshore wind	£72	£65	£137	£147
Gas (with CCUS)	£105	£26	£131	

OBR System Costs Adjusted to 2025 Prices[25]

However, the adjustment from 2012 prices to current prices is not enough. The costs of wind and solar even based on 2012 pricing have been under-estimated in government forecasts[24]. The levelised costs of energy from one source compared with another does not allow for the fact that power produced when people need it at 6 o'clock in the evening on a dark evening is worth a lot more than power produced at 4 o'clock in the morning when people are sound asleep and power demand has fallen. Solar looks very cheap, because it is very cheap to produce when the sun is shining, but it needs back-up not just from batteries but also other technologies to keep the lights on all year round. On that basis, the back-up, peaking and system costs of power are well-known and have been discussed by, among others, the Office of Budget Responsibility (OBR). Biomethane compares well precisely because it can be easily compressed, stored and used when demand is high. The following table sets out the OBR's estimates of cost including the system costs. These OBR estimates from 2023 have been adjusted to allow for recent cost and price developments.

Even these OBR-style system costs are not, though, the final word. The benefits of negative emissions outlined in this report also need to be considered, as they allow hard to replace technologies – for example, diesel engines in heavy goods vehicles – to continue, saving costs for the economy as a whole. Looking at the model runs that ADBA completed with BMA, we see that there are net savings on the pathway to net zero of £298 billion (at net present value). These savings are not all taken into account even in the type of calculation that the OBR made of electricity system benefits (or costs in the case of intermittent renewables like solar and wind). Yet the ability to continue with high-cost-to-abate technologies – precisely because biomethane is capturing enough CO_2 to offset their emissions – is a real economic benefit to society.

Every extra MWh of biomethane therefore saves society costs, offsetting the costs of the production of biomethane. Indeed, each additional TWh of biomethane can save the UK an additional £28m[26]. This fundamentally changes the picture for the cost of energy affordability on the route to net zero. **Biomethane emerges as either competitive or cheaper than other renewables when system costs and benefits are considered**. To reach a first estimate of the total benefits per MWh, ADBA has attributed the total system-wide cost savings from the carbon removal and low carbon energy from AD to biomethane production and reduced the total costs of production accordingly. On that basis, the cost per MWh of biomethane falls to £48[27]. The following bar chart sets out the comparable figures.

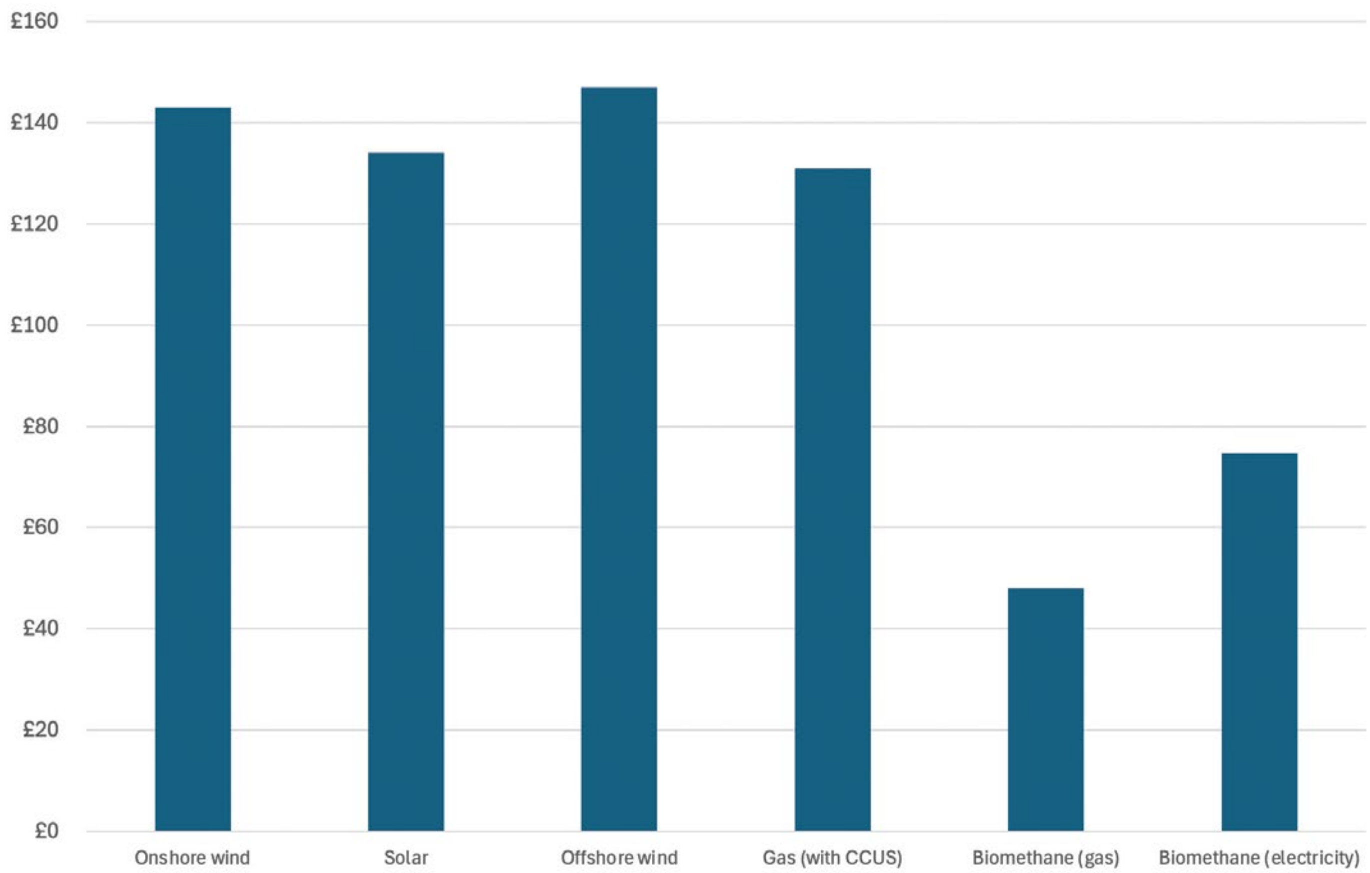
What is the carbon value to a UK AD operator if they were properly supported under the ETS? If the UK ETS recognised the value of biomethane transported by the gas grid, this could be worth around £11/MWh on the current carbon costs, saving the user ETS payments which can pass up the supply chain. Greenhouse gas removals could be worth a further £7/MWh, on the assumption that the carbon permits price will be the same for removals. So, the carbon mitigation value of the technology examined in this report has the potential to be worth a total of £18/MWh within the conventional framework of the UK ETS.

24 http://obr.uk/download/july-2023-fiscal-risks-and-sustainability-charts-and-tables-chapter-3

25 https://obr.uk/box/a-more-comprehensive-measure-of-the-costs-of-energy

26 Getting to 100TWh in 2050 on a smooth ramp produces 10492TWh, and dividing the £298bn system saving by this integrated volume of biomethane gives the unit reduction compared with the modelled price of £77 per MWh.

27 Based on £11 for ETS discount for biomethane zero rating and £7 income for GGRs /MWh.



2025 Enhanced Levelised Costs Accounting for System Costs

Conclusion

The availability of a cheap way of capturing naturally-occurring CO_2 – through the biomethane purification process – is an enormous opportunity for the UK government and the UK economy. Extending CO_2 capture to existing plants, and making CO_2 storage capacity available, would ease many of the constraints on businesses during the transition to the goal of zero carbon emissions (on a net basis – balancing removals of carbon with emissions of carbon) and foster British competitiveness. It could also create a pioneering green industrial sector with enormous export potential.

However, the UK government has to tackle the obstacles facing the biogas sector with speed. The impending end of the GGSS in 2028 is already stalling investment in the sector as investors worry about projects being completed within the deadline, so extension is essential to retaining momentum in the industry. The follow-on mechanism needs to consider the option to convert existing plants – AD plants historically supported by legacy schemes to feed electricity into the grid, rather than inject gas - to avoid wasted investment and maximise the biomethane opportunity.

As a part of these developments, it is essential that biomethane is properly integrated into the UK ETS so that it is not treated like a fossil gas – an anomaly which the UK government has already admitted is mistaken. This will encourage mass balancing – the process of injection in one part of the gas grid, abstracting the gas in another. The UK government's GGR mechanism needs to incorporate non-pipeline transport – the "virtual pipeline" - for bioCO_2 transport and storage from the beginning and not add it on as an after-thought. This will ensure that biomethane producers have an incentive to capture the bioCO_2 and make the mechanism available to industrial users who may not be able to find alternative decarbonisation mechanisms, not least of electricity generation aimed at providing power at peak times of demand.

A big commitment to biomethane should be supported with proven policies such as socialisation of grid reinforcement costs (sharing the costs of gas grid connection across all users) and clear biomethane blending targets as seen in France and Brazil. That will support the production of the bioCO_2 that can then be moved to injection hubs for storage or taken to use in industrial applications if it is not used for carbon removals. There should be no penalty for non-pipeline access to the CO_2 transport and storage system over and above any necessary transport cost difference.

Most important of all is the action which is cheapest: an overall commitment to a biomethane target as part of the transition to net zero. The sector has been bedevilled by stop-start policies like Renewable Obligation Certificates (ROCs), Feed-In-Tariffs (FiTs), RHI and now GGSS. A commitment from the Government to a target would give the sector a long-term goal, facilitating planning, and assuring all those who work in the sector – or who would like to work in it – that the UK government recognises their part in the long-term solution to our climate emergency.

MAKE IT HAPPEN!

ADBA's Plan for Growth and Jobs in Great British Green Gas

1. **The Government should commit to a long-term target for green gas.** The green gas sector – biomethane - needs an end to stop-start support schemes.
2. **Extend the Green Gas Support Scheme by two years until longer-term support arrangements have been put place.** The 2028 deadline is already blocking projects where investors worry that they cannot be built in time.
3. **Stop the UK Emissions Trading Scheme penalising biomethane as if it were fossil gas, bringing it into line with the EU.** The UK government recognises this penalty is wrong but has not yet changed the rules.
4. **Require green gas to be blended into the gas grid to sustainably raise demand.** Such a blending mandate should rise to meet the overall target.
5. **Stop the closure of old biogas plants by supporting their conversion to biomethane injection.** Old plants are closing when failed equipment is too expensive to replace because old schemes – ROCs and FITs – are ending.
6. **Extend the UK ETS to reward capture of bioCO_2 through trucked deliveries to injection points at launch.** The AD process is the cheapest and most assured way of capturing CO_2 and should be supported from the beginning.
7. **Ensure the cost of connecting green gas plants to the grid is spread across the network.** Gas grid connections are easy and cheap compared with electricity grid connections, but the cost is slowing down build-out.
8. **End the need to inject propane into biomethane before injection into the grid.** The UK insists that fossil propane is injected into biomethane to target a very specific calorific value. This is costly, polluting and unnecessary.
9. **Provide local councils with planning guidance on the benefits of green gas.** Too many local authorities still try to re-examine green gas plants as if they were a new technology: provide guidance to explain their benefits.
10. **Allow AI data centres to run electricity generators from the gas grid if they have offtake agreements for biomethane by 2030.** Biomethane can provide the clean power needed for AI data centres.
11. **Speed up big green gas plants through recognition as National Significant Infrastructure Projects.** Priority should be given to groups of biomethane plants in development to serve AI data centres.
12. **Cut permitting delays by ensuring staffing levels at Ofgem and the Environment Agency.** Though the EA has improved, Ofgem can be slow and bureaucratic in dealing with the sector. Similarly fund the devolved environmental regulators to cope.
13. **Encourage small on-farm plants with both permitted development rights and pre-permitting for approved installations.** The pioneering UK technology now exists to decarbonise dairy and other livestock farming. Make it easy.
14. **Boost the use of biofertiliser – the by-product of biogas - as a replacement for synthetic fertiliser by encouraging standardised products.** It is easy to use the highly polluting – now all imported - synthetic fertiliser. Farmers need help to replace it with a biofertiliser made from green gas digestate.

GLOSSARY

AD Anaerobic digestion, the process whereby a plant takes organic matter (e.g. sewage sludge, farm wastes, food and drink industry wastes, local council food waste) and turns it into biogas and biofertiliser.

ADBA The Anaerobic Digestion and Bioresources Association, representing over 750 plants across the UK that use AD to produce green gas.

ADECCS Anaerobic Digestion Energy Carbon Capture and Storage is the process of capturing bioCO_2 during the purification of raw biogas and then storing it safely in long-term safe geological structures (such as North Sea gas fields).

Biogas Biogas is the raw gas that comes out of an AD digester, composed roughly half of biomethane (a near perfect substitute for fossil "natural" gas) and half of carbon dioxide (CO_2).

Biogas purification Biogas must be purified into biomethane – an exact molecular substitute for fossil methane – before its injection into the gas grid.

BECCS Bioenergy Carbon Capture and Storage is the capture of exhaust carbon emissions from the burning of wood pellets and other sustainably sourced biomass, and then the storage of the carbon in long-term safe geological structures (such as old North Sea gas fields).

BioCO_2 The naturally created CO_2 that would normally form part of the natural growth and combustion cycle – absorbing CO_2 during plant growth but releasing CO_2 again during combustion. This is in contrast to the CO_2 emitted when a fossil gas is burned, which creates a net addition to the store of CO_2 in the atmosphere.

Biomethane The green gas that results from the purification of biogas into its two main gas streams: biomethane (a substitute for fossil methane in "natural" gas) and CO_2.

Carbon storage Carbon storage can in principle be provided safely in repurposed North Sea gas fields (where fossil gas had been sealed in place for millions of years) and other geological structures (such as saline aquifers). Work is also underway to develop materials (such as artificial stone) that might economically incorporate stored carbon. Natural carbon sinks like forests also store carbon as tree growth absorbs CO_2.

CCS Carbon Capture and Storage is the projected process by which CO_2 or other greenhouse gases are captured and stored safely before reaching the atmosphere and exerting global warming potential.

CCUS Carbon Capture Use and Storage describes the potential use of carbon through techniques such as its incorporation in artificial stone.

CO_2 Carbon dioxide, the most common greenhouse gas.

DAC Direct Air Capture technologies, currently in the early stage of development, are designed to take greenhouse gases directly out of the atmosphere and create negative emissions.

DACCS Direct Air Capture (see above) combined with Carbon Storage (see above).

EfW Energy from Waste, the process of generating energy - usually electricity or heat - by burning or processing waste materials.

GWh Gigawatt hour, a common measure of large-scale energy output (see MwH). There are 1,000 MWh in a GWh, and 1,000 GWh in a terawatt hour (see TWh). The UK gas grid supplies about 700 TWh of energy each year, while the UK electricity grid supply about 300 TWh of electricity.

Greenhouse gas Any gas that warms the atmosphere such as carbon dioxide (CO_2) and methane (CH_4).

GGR Greenhouse Gas Removals are any process that removes greenhouse gases from otherwise reaching the atmosphere. See ADECCS, BECCS, DACCS.

GGSS Green Gas Support Scheme. The UK Government's main means of supporting green gas, currently due to end in 2028, and replacing three previous schemes which were also time-limited (ROCs, FITS and RHI).

Hub and spoke injection The process of collecting biomethane or bioCO_2 from many dispersed AD plants (the "spoke") and trucking them to an injection point on the gas grid or the future CO_2 collection grid. This is a key part of the "virtual pipeline" for CO_2 captured from AD plants.

Levelised cost The levelised cost of electricity is the cost of delivering a unit of electricity from a particular energy source once all fixed and variable costs (of investment and operating) are considered. However, the calculation does not take account of when the electricity is produced or therefore of how useful it is.

NESO National Energy System Operator, responsible for the electricity and gas grids and for projections or pathways to net zero.

MWh Megawatt hour. The most common measure of small-scale energy output. There are 1,000 MWh in a GWh (see above).

PowerBECCS The process of Carbon Capture and Storage (CCS, see above) from power stations fuelled by biomass (such as the UK's Drax).

System costs Electricity and gas energy systems require grid investment and maintenance, and also back-up supplies when demand peaks above normal capacity levels (as on dark winter evenings) or when supply dips (as when wind or solar power is not available, or outages affect other power supply).

TWh Terawatt hour. The most common measure of very large scale, national energy output. The UK electricity grid supplies ~300 TWh each year, and the UK gas grid supplied about 700 TWh. (See MWh and GWh).

ADBA Anaerobic Digestion and Bioresources Association
THE ENERGY BEHIND THE AD REVOLUTION
Fifth Floor, Riverside Building, County Hall,
Westminster Bridge Road, London, SE1 7PB
www.adbioresources.org company/the-anaerobic-digestion-and-bioresources-association @adbioresources