Green Gas TASKFORCE

A Green Gas Future

Outlining the feedstock potential for biomethane generation

25 September 2025

SGN

September 2025

A Green Gas Future: Outlining the Feedstock Potential for Biomethane Generation

Prepared for the Green Gas Taskforce

alderbioinsights.co.uk

Alder BioInsights

Release Date: September 2025

Authors: Lorenza Carta, Consultant
David Vaughan, Managing Consultant

Reviewer: Lucy Hopwood, Director
Adrian Higson, Director

Disclaimer

Alder BioInsights is a leading international consultancy with expertise on the conversion of biomass to bioenergy, biofuels and biobased products.

Biocentre, York Science Park, Innovation Way, Heslington, York YO10 5NY

+44 (0) 1904 217 182 | enquiries@alderbioinsights.co.uk

alderbioinsights.co.uk

Contents

Acronyms 4
Definitions 5
Executive Summary 7
1. Introduction 11
2. Policy Context 15
2.1 The Drive to Net Zero 15
2.2 Incentives 18
2.3 Other policy areas 19
2.4 Future Policy Framework 23
3. Feedstock Availability & Uses 27
3.1 Feedstock Availability 27
3.2 Feedstock Uses and Competing Demands 43
3.2.1 Feedstock Suitability by Plant Size and Technology 43
3.2.2 Competing Agricultural and Local Uses 44
3.2.3 Cross-Sector Competition for Biomass 45
4. Impacts and Benefits 51
4.1 Carbon Benefits of Crop-Derived Biomethane 51
4.2 Wider On-Farm and System Benefits 52
4.2.1 Case Study: Regenerative Farming and AD at Westbrook Farm 53
4.2.2 Biomethane Potential at Scale 53
4.3 Life Cycle Analysis 55
4.4 Approach 56
4.5 Results 57
5. Conclusions 62
5.1 Policy Recommendations 63

Acronyms

AD - Anaerobic Digestion
ATJ - Alcohol to Jet
Defra - Department for Environment, Food and Rural Affairs
DESNZ - Department for Energy Security and Net Zero
GHG Protocol - Greenhouse Gas Protocol
Bcm - Billion Cubic Metres
BECCS - Bioenergy with Carbon Capture and Storage
BtG - Biomethane to Grid
BUU - Biogas Upgrading Unit
CB6 - Sixth Carbon Budget
CB7 - Seventh Carbon Budget
CCC - Climate Change Committee
CC - Carbon Capture
CCS - Carbon Capture and Storage
CCUS – Carbon Capture Utilisation and Storage
CH_4 - Methane
CHP - Combined Heat and Power
CI - Carbon Intensity
CO_2 - Carbon Dioxide
CO_2eq - Carbon Dioxide equivalent
CS - Countryside Stewardship Scheme
EBA - European Biogas Association
FES - Future Energy Scenario
FIT - Feed-in-Tariff
FT - Fischer-Tropsch
GHG - Greenhouse Gas
GGSS - Green Gas Support Scheme
ha - hectares
kW - kiloWatt
LCA - Life Cycle Assessment
LCFS - Low Carbon Fuel Standard (California)
MJ - Mega Joule
Mt - Million tonnes
NESO - National Energy System Operator
NFU - National Farmers Union
Nm^3 - Normal Cubic Metre
RA - Regenerative Agriculture
RASE - Royal Agricultural Society of England
RED - Renewable Energy Directive
RHI - Renewable Heat Incentive
RO - Renewable Obligation
RTFO - Renewable Transport Fuel Obligation
SAF - Sustainable Aviation Fuels
SFI - Sustainable Farming Incentive
SOC - Soil Organic Carbon
TRL - Technology Readiness Level
TWh - Terawatt Hours

Definitions

Rotational crops (including main crop, cash crop, and break crops):
Alternating crops on a specific field (or fields) in a planned pattern or sequence in successive years. Rotations are typically 4 to 7 years. A long, diverse rotation can support the delivery of multiple environmental and agronomic benefits, including improved soil fertility, increased soil carbon, enhanced crop yields, ground cover and soil protection, pest and disease control, diversified income.

Rotational crops grown for bioenergy include forage maize, hybrid rye, hybrid barley, oats, sugar beet and grass.

Sequential crops (also termed intermediate, second or cover crops):
Two or more crops grown on the same field, one after the other, at different times in the year. Typically, this would involve a main (rotational) crop grown for commercial purposes, and another crop used as cover in the winter or summer months.

Sequential cropping is well aligned with the key principles of Regenerative Agriculture (see Table 2).

Intercropping (also referred to as bi-cropping or companion cropping):
Two crops grown on the same field at the same time, to increase the yield, quality, diversity or resilience on any given field by choosing two or crops that will complement or benefit each other in terms of resource usage and nutrient input.

Current practice is commonly found in cereal crops where a companion of a leguminous species is planted alongside e.g. Rye & Vetch, Barley & Peas. Less common in the UK currently is Maize and beans but elsewhere in Europe this is becoming more popular.

Undersowing:
The main crop can be under-sown with a different species, so when the first (main) crop is harvested, the second grows providing cover and nutrition. The use for this undersown crop could be purely for ground cover or for livestock grazing.

Examples include grass being established between maize rows, or stubble turnips being established in a standing cereal crop.

Energy crops:
Often crops of a perennial nature, that are grown on lower grade or marginal land over a long-time period; typically, woody or lignocellulosic material, better suited to thermal or chemical conversion so targeted for power, heat or Sustainable Aviation Fuels (SAF) production.

Crops grown for biogas such as maize, wholecrop cereals & sugar beet are also commonly referred to as energy crops, but importantly these are rotational crops as defined above and should not be confused with the perennial crops.

Agricultural residues:
a substance that is not the end-product(s) that a production process directly seeks to produce; it is not a primary aim of the production process, and the process has not been deliberately modified to produce it. An example of agricultural residue is straw.

Executive Summary

Executive Summary

Biomethane is a vital component of the UK's Net Zero energy transition. Its potential depends on the sustainable mobilisation of feedstocks across the country, enabling the production of biomethane from anaerobic digestion (AD) at scale. Strategic planning is essential to realise this potential, as supply and distribution challenges, if unaddressed, risk undermining the role biomethane can play in the energy transition and limiting the associated environmental benefits.

The UK has developed a sizeable AD industry over the past 25 years, with a current installed biomethane capacity of over 7 TWh. Growth to date has been driven by support schemes focused primarily on renewable energy production, such as the Green Gas Support Scheme (GGSS), Feed-In-Tariff (FIT), and Renewable Heat Incentive (RHI). These schemes have enabled the sector to expand. However, growth has slowed in recent years due to scheme closures, the narrow focus of existing policy frameworks, and the lack of recognition and reward for the wider environmental and socio-economic benefits of biomethane. Despite these constraints, interest in developing new AD projects remains high, reflecting the breadth of benefits and scale of opportunity the sector offers, and increasingly attracting institutional capital and larger energy sector players.

This report assesses the **availability of sustainable feedstocks in the UK and determines that there is sufficient resource to generate 50 TWh of biomethane per annum by 2030, rising to 120 TWh by 2050**. This analysis demonstrates that feedstock availability is not the limiting factor for sector growth. Rather, constraints lie in the broader policy and regulatory landscape, including planning and permitting delays, grid access challenges, and the absence of a clear long-term policy ambition that can provide confidence to investors and developers.

As biomethane production scales, it is essential to recognise that sustainable biomass is a finite resource and must be directed where it delivers the greatest system-wide benefits in terms of carbon savings, sustainability, and practicality. **Competition** for these resources is expected to grow, particularly from hard-to-abate sectors such as aviation and heavy transport. This raises fundamental questions about allocation, including whether biomass should be directed towards heating, an essential and often hard-to-electrify need, or towards more discretionary uses, such as aviation. Electrification through heat pumps will become increasingly important, but deployment remains limited, with only around 1% of UK homes currently using them. They are not a universal solution, as parts of the existing housing stock often face high costs or technical barriers to retrofitting. In this context, heating applications can serve as a bridging technology, reducing emissions in the near and medium term, while biomethane can also provide renewable heat as an end in itself where electrification is impractical, particularly for high heat applications. Sustainable aviation fuel (SAF) is often highlighted as a potential competitor given its emerging status and significant investment. In practice, however, overlap with AD is limited. Rather than competing, **AD could act as a critical enabler for key future technologies, such as SAF**, providing renewable hydrogen via reforming of biomethane or biogas and biogenic CO_2 and supporting a broader, integrated low-carbon fuel infrastructure. Other biobased processes often viewed as competing for feedstocks remain either at low technology readiness levels or face major policy, economic, and infrastructure barriers

Within the feedstocks analysed, **crops grown either in sequence or rotation** emerge as key enablers to the future potential of biomethane. While such practices are sometimes perceived as competing with food production, studies indicate the opposite: rotational and sequential crops can improve soil health, enhance nutrient cycling, and build organic matter, which over time supports increased yields of all crops, including those grown for food. Farmers rotational and sequential options are dictated and limited by end-markets and regional factors such as climate and soil type. Biomethane production helps broaden the end use options available to farmers where no other mature market exists. By maintaining ground cover and strengthening soil resilience, these additional rotational crop opportunities also reduce dependence on synthetic fertilisers. This creates a positive feedback loop in which crops grown for AD not only deliver renewable energy but also improve the productivity and sustainability of domestic food systems. In this context, cropping for AD should **not** be seen as **a trade-off with food production**, but as a complementary strategy to multifunctional land use that supports agricultural decarbonisation, energy security, long-term food security and nature.

It is clear, therefore, that biomethane production delivers **benefits** well **beyond energy generation**. The largest contributors to UK agricultural greenhouse gas emissions are methane released during manure management and nitrous oxide from fertiliser use. AD of livestock waste can help address these by capturing avoidable methane emissions and retaining nutrients in digestate, which can be applied to land as an organic fertiliser. This provides agricultural and environmental co-benefits such as more effective slurry management, protection of water quality through reduced nutrient runoff, and reduced reliance on imported fertilisers. By capturing these co-benefits, biomethane supports both energy and agricultural decarbonisation, enabling more resilient and sustainable farming systems while contributing to Net Zero targets.

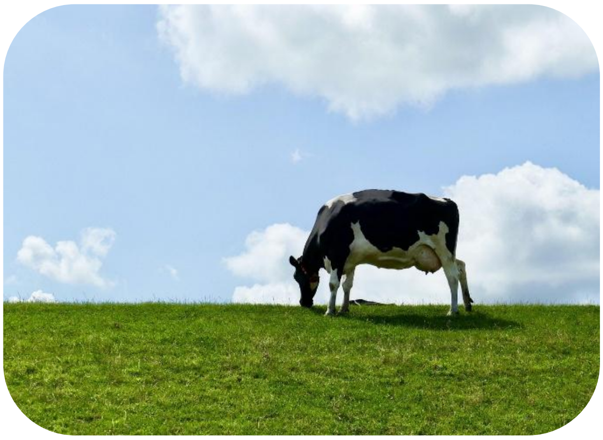
The CCC's Seventh Carbon Budget, however, takes a narrower view of feedstock availability for bioenergy applications, focussing on perennials such as miscanthus, short rotation coppice and forestry residues, feedstocks generally more suited to thermal or chemical conversion for power, heat or SAF. This approach largely sidelines annual arable crops grown in sequence or rotation, underestimating their potential to supply additional biomass without displacing food and to support more integrated farming and energy systems.

Currently, the value of all carbon savings is captured within the energy policy framework, leaving the **agricultural benefits of AD largely unrecognised**. These benefits are critical to improving the long-term economic and environmental viability of the sector. Recognising them within agricultural policy would distribute the financial burden more evenly across sectors, reduce reliance on DESNZ budgets or gas consumer levies, strengthen the economic case for AD by recognising the true the value of digestate and potentially lowering feedstock costs, and position biomethane more competitively alongside other renewables such as wind and solar, which deliver energy without these wider co-benefits. The UK has the advantage of having a **widespread gas grid which makes the full range of feedstocks considered here accessible and economically viable** for biomethane production, regardless of location.

Recent analysis, notably the EBA study *Beyond Energy: Monetising Biomethane's Whole-System Benefits*, highlights the substantial additional value biomethane production offers beyond energy supply alone. For AD, this additional benefit is estimated at approximately £72-150 per MWh of biomethane produced. These added values significantly exceed current production costs for AD biomethane, estimated between £70-78 per MWh (excluding feedstock costs). Furthermore, our analysis shows based on the RED-aligned approach to carbon accounting **cumulative carbon savings across all feedstocks considered could amount to 3.2 $MtCO_2e$ per annum in 2030, rising to 8.8 $MtCO_2e$ per annum in 2050**, making an impactful contribution to Net Zero, with recognition that full system benefits would be significantly higher.

The potential scale of biomethane production highlights the opportunity for transformational growth in the sector and all routes to Net Zero will require the expansion of biomethane production beyond current levels. Strategic deployment will support the UK in meeting its 2030 and 2050 Net Zero targets, providing a buffer for other, less well developed, energy technologies while simultaneously providing substantial socio-economic and environmental benefits. Achieving this growth will require a coordinated approach across government, industry, and other stakeholders, ensuring that regulatory and policy frameworks are sufficiently flexible and supportive to encourage rapid development and investment.

Through developing the Future Policy Framework for Biomethane Production, the UK faces a huge and timely opportunity to revolutionise the sector. To achieve the targeted growth within the next five years, both Government and industry must act swiftly to streamline planning, permitting, and grid connection processes, while also setting a clear long-term vision that minimises risks for developers and investors. Early action to build confidence in long-term growth, coupled with a clear policy focus and recognition of wider environmental and economic co-benefits, will be essential to realising the sector's full potential.



Feedstock Availability

Sustainable feedstock resources in the UK could generate **50 TWh of biomethane by 2030** and **120 TWh by 2050.** Growth is not constrained by resource availability but by policy and regulatory barriers such as planning delays, grid access challenges, and the absence of a long-term AD strategy that provides investor confidence.

Carbon Savings

Net Zero is not possible without biomethane and the gas grid is critical in enabling future growth. This analysis shows that direct carbon savings could reach **3.2 $MtCO_2e$ per annum by 2030, rising to 8.8 $MtCO_2e$ per annum by 2050** as a result; for context, these are equivalent to 6.8% and 18.8% of UK agricultural GHG emissions.

Policy Alignment

UK support for biogas and biomethane has historically focused on **rewarding energy output rather than greenhouse gas savings**. In contrast, international policy is moving towards performance-based incentives that reward verified carbon reductions (e.g. Low Carbon Fuel Standard (California)). Adopting a similar model in the UK would open the door to a wider range of feedstocks, including **sequential crops**, grassland, agricultural wastes and residues, and drive expansion in line with Net Zero objectives.

Cropping, Food Security, and Uncropped Arable Land

Crops for AD should not be seen as competing with food production. When integrated into rotations alongside food crops, they improve **soil health, resilience**, and **food crop yields**. At the same time, they offer a productive use for land that might otherwise remain uncropped or uneconomical. Over the last 15 years, the area of uncropped arable land has varied considerably, yet still averages a significant 262,000 hectares. [40]AD provides a new outlet for this land, helping farmers bring **idle land** back **into productive, profitable** and **regenerative** use.

Wider Co-Benefits

Biomethane production supports carbon savings, energy security, and resilient farming systems. It **reduces reliance on synthetic fertilisers, improves nutrient cycling, enhances slurry management,** and **protects water quality**. These co-benefits underline the role of biomethane as both an **energy solution** and a **driver of agricultural and environmental sustainability**. Recognising and rewarding these wider benefits would further increase sector and business resilience in the future.

Biomass Use Prioritisation

Finite sustainable biomass must be directed where it delivers the greatest value. **Heating**, an **essential** and sometimes hard to electrify need, remains one of the UK's toughest Net Zero challenges. There is no policy driven competition between AD and SAF, as the UK SAF Mandate excludes crop-based biofuels. Instead, AD can enable aviation decarbonisation, since both biomethane and its by product CO_2 are valuable precursors for SAF.

Introduction

01

1. Introduction

Anaerobic digestion (AD) is a biological process that breaks down organic materials, such as food waste, sewage sludge, manure, crops, and crop residues, in an oxygen-free environment. Microorganisms decompose these materials through a series of biological reactions, producing biogas. This biogas typically comprises 50-70% methane (CH_4) and 30–50% carbon dioxide (CO_2), with trace amounts of other gases. The solid or liquid by-product, known as digestate, is commonly used as a fertiliser, providing nutrients and organic matter to soil and crops, much like manure.

Biogas and biomethane are flexible sources of renewable energy, primarily used for electricity generation, heating, and as a transport fuel (Figure 1). In a typical facility, biogas from AD is either combusted in combined heat and power (CHP) units to generate electricity and heat or upgraded to biomethane in a biogas upgrading unit (BUU), where methane is separated from CO_2. The resulting energy can be used on-site or exported, while biomethane can be injected into the gas grid and used for heating, transport, or chemical processes.

Upgrading biogas to biomethane produces biogenic CO_2 as a by-product, which is often vented to the atmosphere. However, there is growing interest in capturing this CO_2 due to supply limitations, rising market value, and the opportunity to enhance sustainability credentials, particularly in consumer-driven industries such as beverage production, horticulture, and livestock slaughtering. In this context, integrating carbon capture and storage (CCS) with biomethane production, commonly referred to as BECCS, positions it as a promising negative emissions solution.

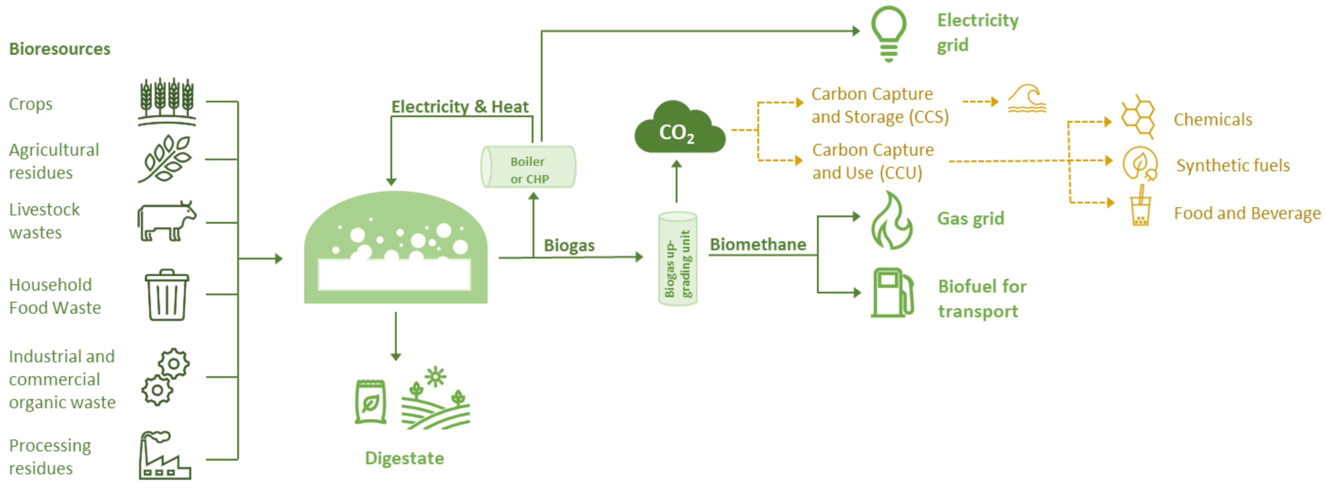


Figure 1. Overview of biogas and biomethane production, illustrating potential pathways, representative of a typical UK facility.

The UK has developed a sizeable AD sector over the past 25 years, with an installed capacity currently around 21 TWh (Table 1). Although on-site CHP remains dominant in terms of plant numbers, largely due to early, generous support, the focus has shifted towards biomethane production, which offers improved efficiency in energy generation, distribution, and storage. The UK is on track to deliver over 10 TWh of biomethane capacity by the end of this year, reflecting growing industry and policy interest.

Table 1. Biomethane installed capacity in the UK by plant type. Values show installed capacity for operational BtG plants and potential capacity for CHP plants if converted, in TWh.

Plant type	Number of plants	Installed Capacity in TWh*
Combined Heat and Power (CHP) - electricity	530	10.1
CHP - heat		~4.0
Biomethane-to-Grid (BtG)	130	7.3
Total	**660**	**21.4**

* CHPs stated as biomethane equivalent for comparison

This momentum has been driven by various support schemes aimed at expanding renewable energy generation from technologies such as AD. Whilst growth has slowed, the development pipeline remains strong given the significant commercial opportunities the sector presents, and AD is considered favourably when compared to other renewables such as wind and solar, due to the multitude of other benefits beyond energy, presenting a more circular solution.

Figure 2 illustrates how growth plateaued toward the end of earlier support schemes like the Feed-In-Tariff (FIT) and the Renewable Heat Incentive (RHI), which expired in 2019 and 2020 respectively, with replacement schemes, notably the Green Gas Support Scheme (GGSS) having a narrower scope and more modest ambitions. Coinciding with the launch of GGSS on 30th November 2021, the rollout of the Simpler Recycling initiative in England was delayed meaning commercial and household food waste has been less available in the early years of the scheme than anticipated: 31 local authorities have agreed transitional arrangements for separate food waste collections at varying dates between 2026 and 2043, thus impacting availability over time.

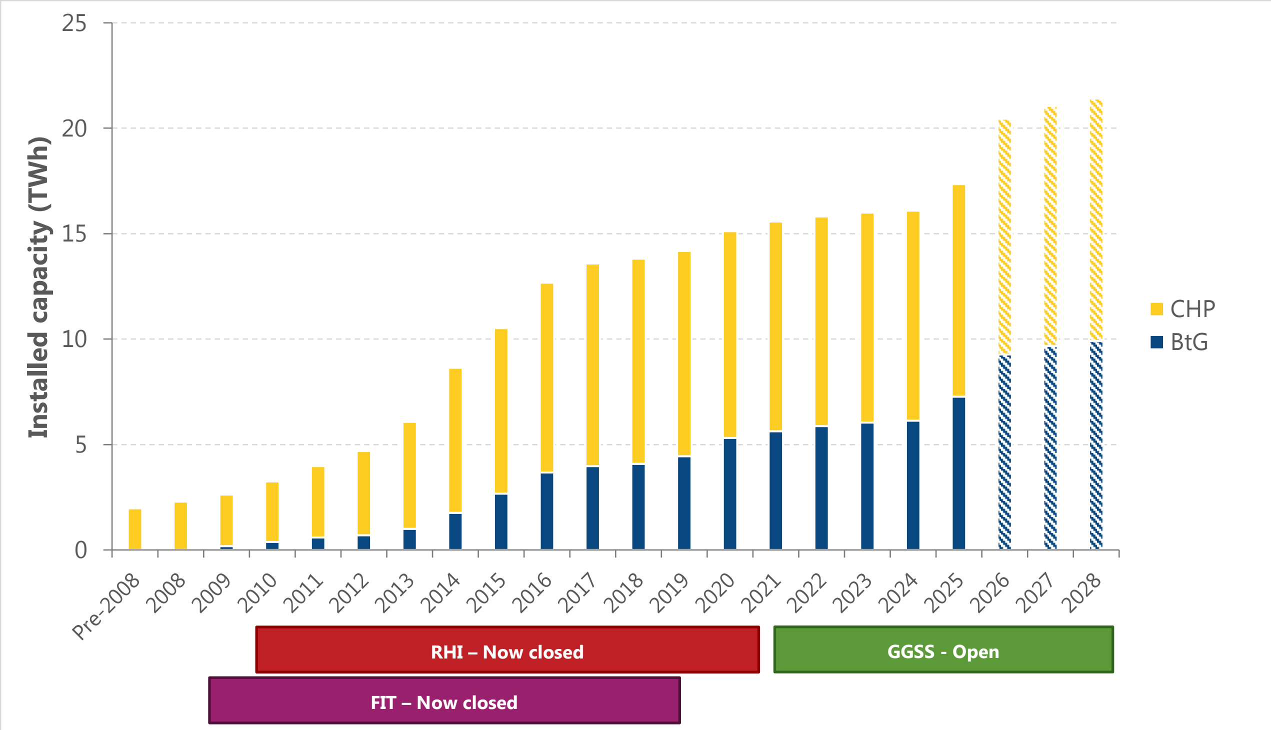


Figure 2. Cumulative AD installed capacity (TWh), by plant type, in the UK, and expected growth over the coming years.

The GGSS is expected to contribute up to 8 TWh of biomethane generation by 2030 but is scheduled to close to new capacity on 31st March 2028. Specifically, the scheme is anticipated to support annual biomethane output of up to 2.8 TWh, with peak production projected between 2029/30 and 2040/41 once all supported facilities are fully operational.[1] This level of output would require approximately 40-45 new biomethane plants during the scheme's lifetime (2021–2028), based on an average plant capacity of around 700 nm³ per hour. However, to date only 19 facilities have secured a GGSS tariff guarantee, so further action is required to meet the desired level of ambition.

Given the long lead times associated with project development, it is expected that schemes without consent by early 2026 may risk not meeting the GGSS commissioning deadline, making investment challenging. To support continued deployment, the Department for Energy Security and Net Zero (DESNZ) is working on a Future Biomethane Policy Framework, with a consultation expected by Spring 2026. Ensuring a smooth policy transition, ideally with an overlap between the GGSS and the future framework, is essential to avoid a hiatus in support and a stalling of momentum, as seen when previous schemes have come to an end.

Biomethane production in the UK currently relies on a mix of feedstocks Figure 3(Figure 3), with the largest contribution coming from crops, primarily wholecrop cereal silage and grass silage. These are followed by a range of waste and residue streams, including sewage sludge, food processing residues, and agricultural residues. Livestock manures and slurries, however, remain significantly underutilised. Despite their abundance and strong greenhouse gas mitigation potential when processed through AD, due to their relatively low energy value the UK AD sector has only developed capacity to treat around 3.5% of collected livestock waste to date, with the majority still applied to land untreated. Processing livestock waste through AD captures methane that would otherwise be released into the atmosphere while retaining its fertiliser value as digestate, which often offers superior agronomic benefits compared with raw manure, with nutrients more readily available to crops and easier to manage because of more consistent

[1] Department for Business, Energy & Industrial Strategy, 2021. *Green Gas Support Scheme: Impact Assessment*. [online] Available at: https://assets.publishing.service.gov.uk/media/61422e36d3bf7f05aa5f92d8/green-gas-impact-assessment.pdf (Last accessed June 2025)

production and routine testing. Furthermore, processing this waste through AD presents an opportunity for improved storage, distribution and spreading, allowing for more effective management and use on farmland.

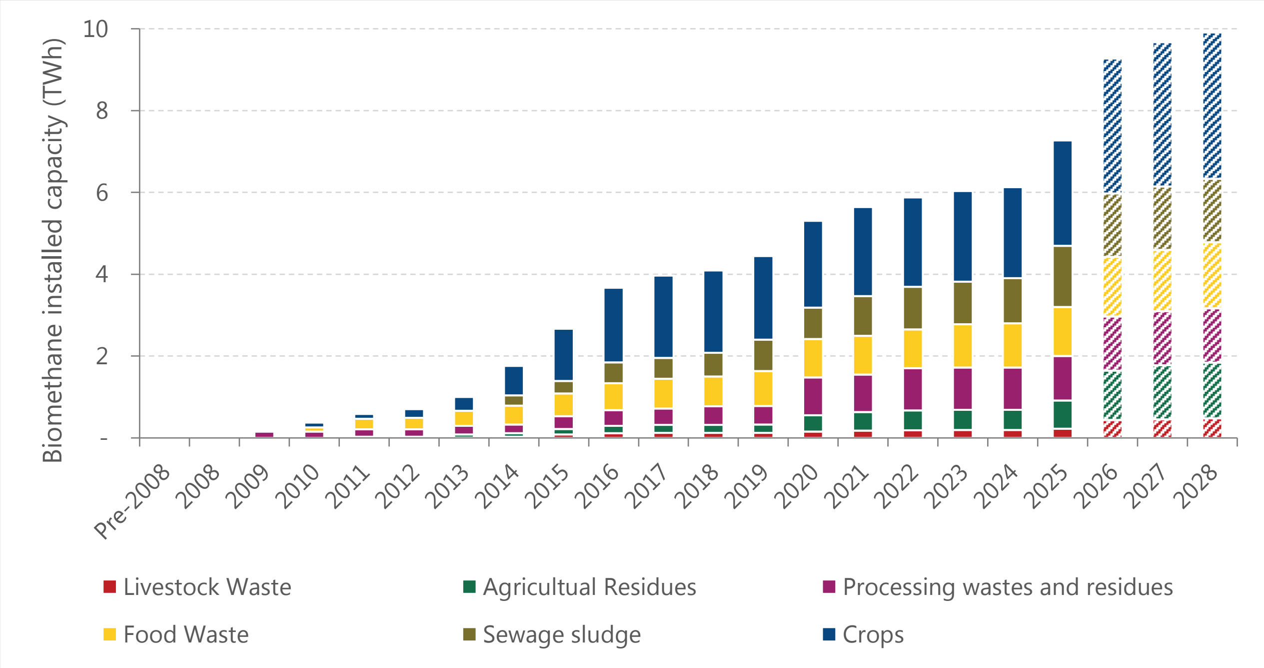


Figure 3. Biomethane installed capacity in the UK by feedstock type (TWh per year).

Historically, UK support mechanisms for biogas and biomethane have focused on rewarding energy output rather than greenhouse gas (GHG) savings, so lower energy-yielding feedstocks have been less attractive. In contrast, international policy trends are shifting towards performance-based incentives that reward verified carbon reductions - an approach more closely aligned with Net Zero objectives. This model has proven effective in accelerating capacity growth in other regions and has broadened market interest beyond traditional energy sectors. A similar change in approach in the UK would make a broader range of feedstocks more commercially attractive, including agricultural wastes, residues and crops whilst presenting a major opportunity for expansion, particularly considering growing interest in circular, low-emission farming systems.

To encourage and accelerate future growth, support mechanisms need to be more flexible and recognise the full range of benefits biomethane offers beyond energy production, including its positive impacts on the farming and food sectors. A diverse and reliable feedstock supply is fundamental to this expansion, but growth is constrained by GGSS eligibility criteria, where wastes and residues are prioritised in line with specific feedstock restrictions[2], and the broader environmental contributions of AD are not recognised, valued and rewarded. Beyond the GGSS, there is a clear opportunity to broaden and diversify feedstocks UK-wide, accelerating sector growth while delivering net negative emissions and strengthening UK energy resilience.

This report considers availability and use of sustainable feedstocks for AD in the UK, quantifying arisings, competing demand and remaining availability over a 25-year period, from 2025 - 2050. Further detail on the policy landscape is initially discussed (Section 2), before considering availability and competition for each feedstock type in detail, to quantify the scale and rate of growth over time (Section 3). The report then goes on to discuss the impacts of delivering such growth, thinking beyond energy to the wider benefits and the interaction with other policy areas, most notably waste and agriculture (Section 4), before concluding the analysis and setting out policy recommendations and actions required to deliver growth at pace (Section 5), to support the UK in meeting the legally binding Net Zero target by 2050.

---

[2] Feedstock restrictions stipulate that at least 50% of the annual biomethane output from a GGSS accredited plant must be derived from wastes and residues. Where the 50% limit Is breached, payments will be adjusted accordingly.

Policy Context

02

2. Policy Context

The promotion of energy from renewable sources within Europe is defined under the second (2018/2001)[3] and third (2023/2413)[4] iterations of the Renewable Energy Directive (RED 2009/28/EC). The European Commission adopted the 'Fit for 55' package in 2021, which adapted existing climate and energy legislation to meet the new European Union (EU) objective of a minimum 55% reduction in greenhouse gas (GHG) emissions by 2030. RED III aims to significantly reduce greenhouse gas emissions by promoting renewable energy sources. It mandates a minimum 42.5% share of renewable energy in overall energy consumption by 2030, with an ambition to reach 45%.

Under the Renewable Energy Directive sustainability criteria for biofuels (incl. bioenergy) were initially defined in Article 17 of RED with further expansion and clarification under REDII and RED III. RED II details that feedstock use should follow the waste hierarchy established in the Waste Framework Directive (2008/98/EC)[5]; follow sustainability criteria for the Union; and ensure that feedstock use for biofuels (incl. bioenergy) should not create additional demand for land or distortion to markets for (by-)products, wastes and residues. Article 26 of RED II sets limits on the use of food and feed crops (which include starch-rich, sugar and oil crops) to prepare for and promote the transition towards advanced wate and residue-based biofuels. RED II further promotes the expansion of feedstock supply from timber and agricultural sources as far as these align with sustainability and GHG criteria. Agricultural practices used for production of biofuels should be consistent with improvements in soil quality and soil organic carbon and lead to improved biodiversity and carbon stocks.

A risk-based approach is taken with high biodiversity and high carbon stock land given protections from use. The Directive recognises the impacts of indirect land use change which could be caused by using food and feed crops and sets limits on these feedstocks to avoid direct and indirect damage to high carbon stock and biodiverse land through land use change. The Directive also promotes the restoration of damaged or degraded land. Furthermore, the Directive promotes the use of international voluntary schemes to ensure sustainability compliance in accordance with established sustainability criteria and GHG thresholds and the way in which GHG savings should be calculated is also set out. Finally, RED III introduces principles of cascading use of biomass in support of the circular economy, with feedstocks to be prioritised for economic and environment value as a method for improving resource utilisation.

Although the UK has now been released from the renewable energy targets under RED II/III following Brexit, the UK-EU Trade and Cooperation Agreement[6] includes a commitment to promote energy efficiency and the use of energy from renewable sources. It also states a reaffirmation of the EU’s 2030 targets and the UK’s 2030 ambitions for renewable energy and energy efficiency, with the aim of achieving a 100% reduction of greenhouse gas emissions by 2050 compared to 1990 levels (the Net Zero target) in the Climate Change Act 2008 (2050 Target Amendment).

The EU has set ambitious but not legally binding targets for the expansion of biomethane production as part of the REpowerEU (2022)[7] plan with the aim of producing 35 bcm (~350 TWh) per year by 2030. While production has increased significantly, forecasts suggest that only 10 bcm (~10 TWh) per year will be achieved by 2030.

The UK does not have a specific target for biomethane production or use but has considered how biomethane could contribute to Net Zero, as discussed below.

2.1 The Drive to Net Zero

The UK is legally obligated to achieve Net Zero greenhouse gas emissions by 2050. The target was enshrined in the Climate Change Act of 2008[8] and through a 2050 Target Amendment Order (2019/1056)[9]. This requires that the UK

[3] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance.). Can be accessed at: http://data.europa.eu/eli/dir/2018/2001/oj

[4] Directive (EU) 2023/2413 of the European Parliament and of the Council of 18 October 2023 amending Directive (EU) 2018/2001, Regulation (EU) 2018/1999 and Directive 98/70/EC as regards the promotion of energy from renewable sources, and repealing Council Directive (EU) 2015/652. Can be accessed at: http://data.europa.eu/eli/dir/2023/2413/oj

[5] Directive 2008/98/EC of the European Parliament and of the Council of 19 November 2008 on waste and repealing certain Directives (Text with EEA relevance). Can be accessed at: http://data.europa.eu/eli/dir/2008/98/oj

[6] UK-EU Trade and Cooperation Agreement 2020 https://assets.publishing.service.gov.uk/media/608ae0c0d3bf7f0136332887/TS_8.2021_UK_EU_EAEC_Trade_and_Cooperation_Agreement.pdf

[7] RepowerEU https://commission.europa.eu/topics/energy/repowereu_en

[8] Climate change act 2008 can be accessed at https://www.legislation.gov.uk/ukpga/2008/27/contents

[9] The statutory instrument 2019 No 1056 The Climate Change Act 2008 (2050 target amendment order) 2019 can be accessed at https://www.legislation.gov.uk/ukdsi/2019/9780111187654

reduces its greenhouse gas emissions by 100% compared to 1990 base levels during this period. In addition, there are interim targets for the UK to reduce GHG emissions by 68% by 2030[10] and 81% by 2035.[11]

The roadmap to these targets is set out in a series of Carbon Budgets based on advice by the Climate Change Committee. Carbon budgets are set 12 years in advance through secondary legislation under the Climate Change Act. The UK's carbon budgets are being gradually reduced over time, with the aim of reaching 'Net Zero' carbon by 2050. The latest is the Seventh Carbon Budget[12] which was published earlier this year and covers the period 2038 - 2042, putting a limit on GHG emissions of 535 $MtCO_{2eq.}$ The budgets set a legally binding cap on the maximum level of emissions ('the net UK carbon account') for a period of five years. In effect, a carbon budget is the amount of carbon that the UK has available to 'spend' in a set time frame.

The advice on the level of the Seventh Carbon Budget is informed by an updated Balanced Pathway. In the Balanced Pathway, biogas is predominantly blended into the gas grid as biomethane displacing natural gas, with this role declining over time as heating is electrified. At this point it is assumed that the biogas is freed up and becomes increasingly available for use in other sectors, reducing the need for gas imports, for heat, power and transport.

The Clean Power 2030 Action Plan[13] sets out a number of scenarios to reduce reliance on fossil fuels for electricity supply by 2030 in GB. While the scenarios do not specifically include biomethane production in the technologies available it does acknowledge that biomethane could play a role and can be flexible across many different end-uses such as heat, power, transport, agriculture, and hydrogen production. The action plan puts a great deal of emphasis on the role of hydrogen and nuclear in delivering the future energy needs, but it also acknowledges that a number of the current power stations are expected to come offline by 2030 and that new facilities will not be operational until between 2029 and 2031 leaving an evident gap in provision. The Action Plan also recognises challenges associated with hydrogen deployment, considering the investment risk from being a new technology alongside the need for grid scale infrastructure providing transport and storage capacity which can have long lead times.

Future Energy Scenarios (FES)[14] was published by NESO in 2025 and sets out three potential pathways for reaching Net Zero by 2050. The pathways consider the different ways Great Britain can achieve a Net Zero energy system and the scale and nature of emissions reductions along the way. The three pathways are:

- **Holistic Transition:** Net Zero is met through a mix of electrification and hydrogen. This scenario requires strong consumer engagement through adoption of energy efficiency improvements and a change in demand, and reflects a high-renewable capacity pathway, with unabated gas dropping sharply. Only moderate levels of nuclear capacity are included, and low levels of hydrogen for dispatchable power. No unabated gas remains on the network in 2050.

- **Electric Engagement:** Net Zero is met mostly through electrified demand with strong consumer engagement. This pathway requires high levels of nuclear power and renewables and has the highest levels of bioenergy with carbon capture and storage across all scenarios.

- **Hydrogen Evolution:** Net Zero is met through fast progress for hydrogen in industry and heat. Widespread access to a national hydrogen network is needed and only low levels consumer engagement is required. This pathway has high levels of hydrogen dispatchable power plants reducing the need for renewable and nuclear capacities.

FES 2025 recognises that there is uncertainty in areas such as the speed of technology uptake, the role of both electrification and low carbon fuels and the level of consumer engagement. Alongside the three pathways is Falling Behind where some progress is made but not at sufficient speed to achieve Net Zero.

---

[10] United Kingdom of Great Britain and Northern Ireland's 2035 Nationally Determined Contribution (NDC). Available at: https://assets.publishing.service.gov.uk/media/679b5ee8413ef177de146c1e/uk-2035-nationally-determined-contribution
[11] United Kingdom of Great Britain and Northern Ireland's Nationally Determined Contribution 2022: Available at: https://assets.publishing.service.gov.uk/media/633d937d8fa8f52a5803e63f/uk-nationally-determined-contribution
[12] Climate Change Committee, 2025. *The Seventh Carbon Budget.* [online] Available at: https://www.theccc.org.uk/publication/the-seventh-carbon-budget/ (Last accessed June 2025)
[13] Clean Power 2030 Action Plan. [online] Available at: https://www.gov.uk/government/publications/clean-power-2030-action-plan
[14] National Energy Systems Operator, 2025. *Future Energy Scenarios: Pathways to Net Zero*. [online] Available at: https://www.neso.energy/publications/future-energy-scenarios-fes

The report states that switching to low carbon fuels can increase energy security and contribute to over 50% of whole economy decarbonisation; a crucial part of this decarbonisation is that the adoption of low carbon fuels is fast, to meet carbon budgets and Nationally Determined Contributions (climate action plans submitted by each country under the Paris Agreement). Biomethane is required in all pathways at higher levels than is currently being produced, is considered a central part of decarbonising the gas grid and is expected to supply up to 38% of gas demand in 2050. An assessment of sustainable feedstocks commissioned by NESO to support FES showed that there is availability of feedstock beyond that which is required for the pathways described, so feedstock is not considered a key constraint.

FES 2025's central *Holistic Transition* pathway recommends over 64 TWh of domestic biomethane production by 2050, valuing biomethane's ability to decarbonise hard to abate sectors cost-effectively, practicably, and immediately.

At present, biomethane accounts for only around 1% of UK gas consumption; however, future demand estimates from FES 2025 suggest this share could increase to between 6.5% and 8.3% by 2030, depending on whether Great Britain follows the 'Falling Behind' pathway or the more ambitious 'Holistic Transition' scenario. By 2050, biomethane could supply up to 33.8% of total gas demand under conservative projections, or potentially cover all demand in scenarios where electrification advances at a faster pace, reducing overall gas consumption (Figure 4).[14]

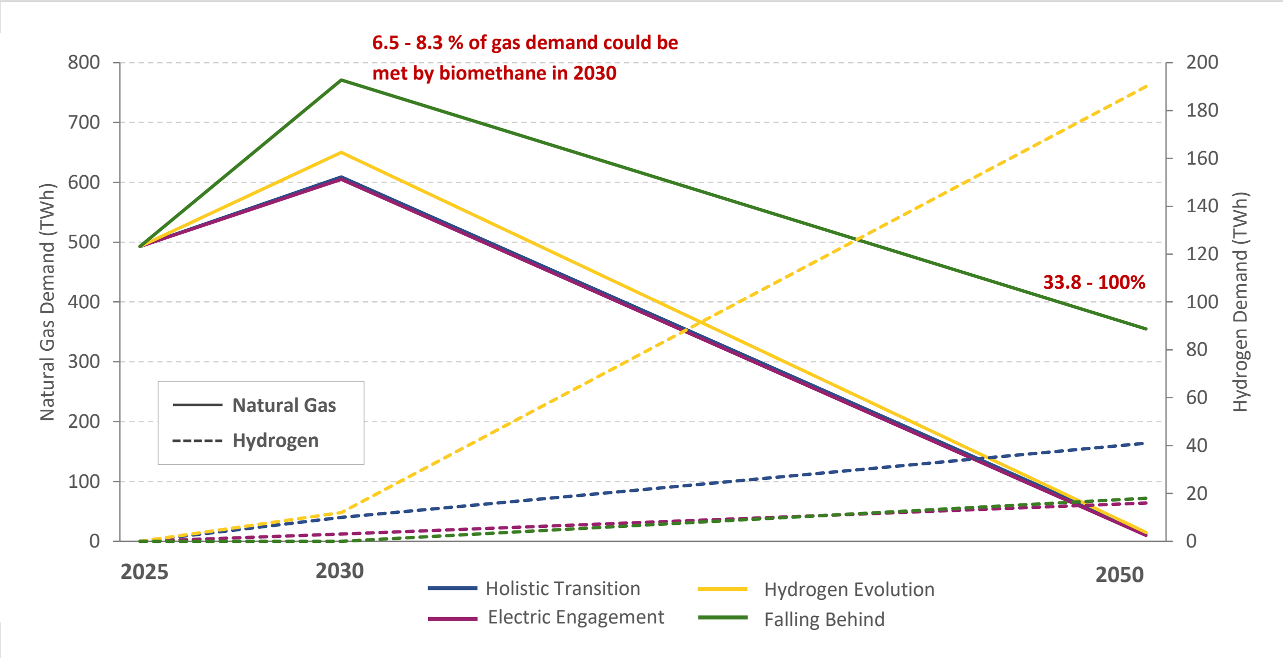


Figure 4. Projected GB gas and hydrogen demand under FES 2025 scenarios[14], showing the potential contribution of biomethane.

FES 2025 noted that renewables and electrification account for the bulk of decarbonisation in the pathways, it also acknowledged the need for carbon capture and storage to deliver the desired GHG savings over time. While it recognised that biomethane includes the ability to capture the CO_2 this contribution was not assumed in the pathways, so actual savings would be expected to exceed those modelled.

It is evident from these high-level policy ambitions and associated delivery plans that there is a need to deliver low-carbon energy growth at pace, and a recognition in many cases that biomethane presents an immediate and scalable solution so should be supported and encouraged. Anaerobic digestion (AD) and the production of biomethane is a well-established technology in the UK and Europe offering a commercially ready route, providing immediate emissions reduction and tried and tested integration with existing gas infrastructure. Policy and incentives over the years have played an important role in the development of the AD industry with an evident shift from a renewable energy focus to a decarbonisation approach to achieve Net Zero targets. Further detail on past, present and future support for the biomethane sector is discussed below.

2.2 Incentives

Historically the incentives for biogas and biomethane have revolved around the Feed in Tariff (FIT) and Renewable Heat Incentive (RHI). The FIT was introduced in 2009, providing tariff-based support for domestic and industrial scale low-carbon electricity generation in GB. The FIT Regulations were amended in 2017[15] to add a requirement for at least 50% of electricity generated via AD to be derived from wastes or residues, focussing growth on these areas.

The non-domestic RHI was then introduced in 2011, offering tariff-based support for low-carbon heat production, including via biogas combustion and biomethane injection to grid in GB. This mechanism was similarly amended in 2018[16] for new sites stipulating that at least 50% of the resultant output must be derived from wastes or residues. As with the FIT this was seen as an attempt to encourage greater use of wastes and to reduce crop input given concerns around land use whilst also addressing the need for greater waste treatment capacity in the near term.

There is currently around 7 TWh of biomethane production capacity in the UK[17] most of which is supported by the RHI, Renewable Transport Fuel Obligation (RTFO) or the GGSS. The Biomass Strategy (2023)[18] outlined the requirement for 30-40 TWh of biomethane production by 2050 to help achieve Net Zero targets. Further to this FES 2025 states that it could be as much as 64 TWh depending on which pathway is followed.

Biomethane production is currently incentivised through the Green Gas Support Scheme (GGSS)[19] in GB, which ends in 2028. This is also a tariff-based mechanism with a tariff period of 15 years and provisions following on from FIT and RHI with the same requirement for at least 50% of the total annual biogas output (by energy content) to be derived from wastes or residues.

Within all support schemes to date, sustainability requirements have included both GHG criteria and land use criteria. Land use criteria are intended to ensure that the biomass used for biomethane production comes from sustainably managed land. This includes protecting ecosystems and the environment and adhering to sustainable forestry management practices, where appropriate. The GHG criteria considers the emissions associated with biomethane production, from feedstock production and procurement to the point of injection (RHI/GGSS) or use (RTFO). Under all schemes a GHG threshold has been set, aligned with varying methodologies underpinned by the Renewable Energy Directive (RED) and more recent iterations. All biomethane produced for injection under GGSS must demonstrate lifecycle GHG emissions below 24g CO_2 per megajoule, down from the 34.6 g CO_2 per megajoule on the RHI.

To determine how emissions should be calculated, and from which point in the production or procurement process they must be included, feedstocks are broadly categorised under the following definitions:

- **Products:**
  These are feedstocks where the primary reason for their production (or collection) is for use in AD. Examples include crops like maize, wholecrop cereals and sugar beet.
- **Co-products:**
  These are materials produced deliberately alongside a main product, where AD is not the primary purpose, but they are suitable as feedstocks due to their composition. Examples include rapeseed meal derived from oilseed rape following oil extraction, and brewers' grains derived from wheat during beer production.
- **Residues:**
  These are materials that are not the primary aim of a production process and are not deliberately produced. Examples include cereal straw, unsalable vegetables, and peelings or residues from processing.
- **Wastes:**
  These are substances that would otherwise be discarded or that the holder is required to discard. Examples include food waste from domestic properties, food waste from commercial catering operations, sewage sludge, and animal slurry or manures.

---

[15] Feed-In tariffs (Amendment) Order, 2017. [online] Available at: https://www.legislation.gov.uk/uksi/2017/131/
[16] Non-Domestic Renewable Heat Incentive Scheme Regulations, 2018. [online] Available at: https://www.legislation.gov.uk/ukdsi/2018/9780111166734
[17] Alder BioInsights, 2025. *Anaerobic Digestion (AD) Deployment in the UK 2025. Available at: https://www.alderbioinsights.co.uk/what-we-do/reports-and-tools/uk-ad-deployment/*
[18] DESNZ, 2023. Biomass Strategy. [online] Available at: https://www.gov.uk/government/publications/biomass-strategy
[19] Green Gas support Scheme, 2021 [online] Available at: https://www.gov.uk/government/publications/green-gas-support-scheme-ggss

These definitions are also important in determining where emissions and savings should be allocated when considering alternative approaches to carbon accounting, as discussed in later sections.

2.3 Other policy areas

Renewable Transport Fuel Obligation (RTFO) and Sustainable Aviation Fuel (SAF) Mandate[20]
The RTFO, introduced in 2008, aims to reduce GHG emissions from the transport sector by encouraging the production and supply of low-carbon fuels, including biomethane, to the transport sector across the UK. This now includes road vehicles, non-road transport (non-road mobile machinery, inland waterway vessels, recreational craft, power trains and tractors) and certain marine applications with the aim of reducing emissions from this sector. The RTFO operates on a volumetric basis, with annual obligations set for fuel suppliers to ensure a certain percentage of their fuel comprises sustainable low-carbon fuel.

In contrast, the SAF Mandate, launched on 1st January 2025, focuses on delivering GHG emission savings in the hard-to-abate aviation sector through supply of sustainable aviation fuels (SAF). The SAF Mandate explicitly excludes SAF produced from food, feed, or energy crops, aiming to prioritise waste and residue-derived biofuels to mitigate concerns over food security and land use pressures, whilst under RTFO crop-derived biofuels are supported, limited by a decreasing crop-cap. However, an exception to the crop-cap are non-food cellulosic and lignocellulosic crops, such as miscanthus, switchgrass and ryegrass, which in most cases would receive double reward.

The sustainability criteria applied to the RTFO and the SAF mandate are aligned, ensuring that fuels compliant with the RTFO would also meet the SAF Mandate's requirements, if they adhere to the technical criteria and follow a supported pathway. Both schemes stipulate that any renewable fuel derived from a crop must meet land and soil carbon criteria, while biomass derived from waste must comply with waste management criteria.

The land criteria focus on ensuring that fuel is not derived from land, whether in the UK or overseas, which exhibits high biodiversity value or supports carbon stocks above and below ground, where sourcing of biomass from these areas would lead to adverse effects on the level of carbon stocks. The land criteria also embeds the principles that biomass production should not lead to soil degradation, contamination or depletion of water sources or air pollution.

The Department for Transport (DfT) has confirmed plans to consult on how low-carbon fuels are rewarded under the RTFO, potentially transitioning to a greenhouse gas-based reporting system. Should a greenhouse gas scheme be introduced in the RTFO, there would be no need for a crop cap. This approach would allow crops to be used, provided they have significant GHG savings and low land use impact, thereby encouraging suppliers to employ best practices in crop cultivation.[21]

In summary, while the RTFO currently permits crop-derived biofuels within a decreasing cap or from non-food crops, the SAF Mandate excludes them entirely. The DfT's forthcoming consultation on GHG-based reporting and the potential removal of the crop cap signal a shift towards a more inclusive approach to crop feedstocks, contingent on their environmental performance.

Biomass Strategy
The Biomass Strategy (2023)[18] was devised to determine the role of biomass in the UKs goal of achieving Net Zero. The strategy introduced the government’s commitment to developing a standardised sustainability framework, ensuring that biomass use remained environmentally responsible. It also outlined its intention to maximise domestic supply of sustainable biomass, aiming to monitor UK availability and remove barriers impeding increased supply.
The Strategy identified heat, power and transport as the short- and medium-term uses for biomass. It also noted wider uses for biomass within the products and chemicals sectors. Biogas and biomethane were identified for the heat and power sectors, as well as low-carbon fuels for aviation and marine transport. Carbon capture technologies associated with biomass usage were also mentioned as being crucial for successfully achieving Net Zero.

The Biomass strategy recognised the important roles that residues, wastes and crops can play in the sustainable feedstock mix for AD and biomethane production. Injection of biomethane into the gas grid provides the route to decarbonise a diverse range of sectors, supporting decarbonisation of electricity supply and hard to abate sectors such

---

[20] DfT, *RTFO and SAF Mandate Technical Guidance 2025*. Can be accessed at: https://assets.publishing.service.gov.uk/media/67626f161ca3ec0a49e1908e/rtfo-and-saf-mandate-technical-guidance-2025.pdf
[21] DfT, 2025. *Call for evidence outcome | RTFO statutory review and future of the scheme.* [online] Available at: ://www.gov.uk/government/calls-for-evidence/rtfo-statutory-review-and-future-of-the-scheme (Last accessed September 2025)

as domestic heating, industrial heat and transport. Wastes and residues are a vital part of the AD feedstock mix as these support the circular economy by diverting organic waste from landfills, thereby recycling carbon and reducing the associated environmental impact of landfill activity. The use of crops can also provide an important source of feedstocks for AD if they are grown sustainably and do not lead to detrimental impacts in other parts of the economy. Under the Biomass Strategy a sustainable crop would be part of an integrated crop regime in accordance with good practice, high environmental standards and without leading to indirect Land Use Change (iLUC). The Strategy recognises the role of crop feedstocks to provide a method for managing potential fluctuations within the supply of waste feedstocks to AD. The use of crop feedstocks should be balanced with other priority uses in the economy and not lead to reductions in food security, biodiversity and sustainable land management - this approach is discussed further in later sections.

Simpler Recycling[22]

Food waste is an important feedstock for the biomethane industry, which is sometimes difficult to quantify, access, store and transport. Combined with an ongoing move to reduce waste arisings, as part of the Simpler Recycling Reform in 2023 Defra set out plans for compulsory collection of food waste from domestic and non-domestic properties in England with the proposed timeline being:

- from 31 March 2025, businesses and relevant non-domestic premises in England must arrange for the separate collection of the core recyclable waste streams glass, metal, plastic, paper and card, and food waste, with the exception of garden waste.
- micro-firms (businesses with fewer than 10 full-time equivalent employees) will be temporarily exempt from this requirement and will have until 31 March 2027 to arrange for recycling of core recyclable waste streams
- by 31 March 2026, local authorities will be required to collect the core recyclable waste streams from all households in England, which includes introducing weekly food waste collections for most homes, unless a transitional arrangement has been agreed.

Of 317 Local Authorities in England, 31 have been granted transitional arrangements due to existing long term waste contracts. However, all remaining Authorities must implement collections in line with the timeline above and present the organic fraction (notably food waste) for treatment at suitable facilities, most likely via existing or new AD capacity. Similar initiatives are already in place or are being considered in other nations, all aligning with UK waste reduction strategies. Adoption and participation rates are largely unknown making it difficult to quantify the impact of such reforms; however, such change of policy will inevitably support further AD capacity growth in the near-term.

Sustainable Farming and Regenerative Agriculture

To help improve land management practices and to encourage a more sustainable farming system, Defra launched The Agriculture Transition Plan in 2020[23] which was updated in 2023. The aim of the Plan was to reduce untargeted payments and invest in improving the environment and animal health, reducing carbon emissions and rewarding sustainable farming practices in England. Connected to this are the Sustainable Farming Incentive (SFI)[24] and the Countryside Stewardship Scheme (CS). The overarching aim was to replace the EUs Common Agriculture Policy post Brexit and refocus the incentives on improving practices on an action-based approach rather than simply rewarding land ownership and has been dubbed "public money for public goods". The SFI is currently closed to new applications and is undergoing a review; however, measures in the initial SFI round which launched in Summer 2023 included support for sustainable cropping and livestock production systems which could have delivered benefit to AD. Alongside SFI a suite of grants were also launched for improved productivity and slurry management, through the Farming Equipment and Technology Fund (FETF), and similar mechanisms are available or being considered in other UK nations.

It was evident upon review that none of these agricultural support mechanisms or grant programmes acknowledged or rewarded the role that AD could play in improving productivity or slurry management, as AD was still viewed entirely as an energy vector, rather than being considered more widely for the benefits it could deliver at site- or system-level in agriculture. The analysis discussed in subsequent sections makes a case for better alignment of policies across different Departments, in recognition of these wider benefits and the added value across energy, waste and agriculture.

---

[22] DEFRA, 2024. *Policy Paper | Simpler Recycling in England: policy update.* [online] Available at: https://www.gov.uk/government/publications/simpler-recycling-in-england-policy-update/simpler-recycling-in-england-policy-update

[23] The Agricultural Transition Plan 2021-2024 https://assets.publishing.service.gov.uk/media/60085334e90e073ec94cc80b/agricultural-transition-plan.pdf

[24] The Sustainable Farming Incentive. https://assets.publishing.service.gov.uk/media/6890cccb25ba7325501b09e6/SFI23_handbook_v12.0__August_25

Regenerative Agriculture is a farmer-led movement that aims to work with nature to improve soil health, biodiversity and water quality while maintaining food production and improving resilience to climate change impacts.
The Royal Agricultural Society of England (RASE) lists the five main principles of regenerative agriculture as[25]:

Table 2. Regenerative Agriculture Principles.[25]

Principle	Description	Alignment with AD
1. Minimise soil disturbance	Minimise physical and chemical disturbance to protect micro-flora and fauna. Cultivation can damage the microbiome while the heavy use of fertiliser has negative ecosystem impacts.	Most crop types typically grown for AD can be sown on a minimum tillage basis, reducing the need for deep cultivations and protecting soil structure. Grassland is infrequently cultivated and reseeded.
2. Keep the soil covered	Soil cover with living plants or mulch reduces rain damage to the soil, allows for gentle percolation of water and reduces the detrimental effects of heat and cold.	Integrating winter and summer cover (sequential) crops maintains soil cover year-round, both retaining moisture and preventing run off.
3. Maintain living roots in the soil	Plant root exudates benefit the soil ecosystem. Use of cover crops will maintain living roots within the soil for as much of the year as possible, in turn retaining moisture and improving soil structure to enable effective drainage when moisture levels are high.	Integrating winter and summer cover (sequential) crops provides active root growth year-round, retaining moisture and protecting and enhancing soil structure.
4. Maximise plant diversity	A diverse population of plants can support a wider variety of soil fauna compared to monocultures creating a more robust ecosystem. Crop rotations can ensure healthier soils and reduce weed and disease pressure, naturally breaking cycles and reducing inputs in the rotation.	AD provides an opportunity for growers to consider and grow a more diverse range of crop types, improving diversity of flora and fauna present; providing natural pest and disease breaks; and reducing the need for chemical and fertiliser inputs.
5. Reintroduce livestock (or mimic the benefits of livestock on land)	A diverse population of grazing livestock can boost soil fertility and biodiversity (*as can digestate*). In addition, there is potential to supplement farm income by diversifying revenue and risk.	The use of digestate mimics some of the benefits of livestock presence on farms, delivering organic matter back to the land and providing a natural source of nutrients year-round. The integration of other opportunities AD offers such as undersowing could also support livestock grazing overwinter where it would not typically exist.

The Parliamentary Office of Science and Technology (2025)[26] noted that Defra have acknowledged that regenerative farming can have a beneficial impact on soils, but they are not intending to provide incentives for such activities. They argue that the SFI already addresses aspects of regenerative agriculture and that there is a lack of an agreed universal definition, in addition Defra states that there is a lack of evidence in the UK that regenerative agriculture will support the provision of the public good.

Greater integration of agricultural feedstocks cultivated via rotational or sequential cropping systems offers multiple agronomic and environmental benefits, aligned with sustainable farming practices and the key principles of regenerative agriculture. These crops help protect and improve soil health, provide profitable break crop options, and support healthier, lower-carbon food production systems. Without such crop diversity, the risk of soil degradation, increased pest and disease pressures, and biodiversity loss rises, leading to higher costs and risks for farmers. Thus,

[25] RASE, Principles of Regenerative Agriculture available at: https://www.rase.org.uk/news/the-principles-of-regenerative-agriculture/
[26] UK Parliament POSTnote 748. [online] Available at: https://researchbriefings.files.parliament.uk/documents/POST-PN-0748/POST-PN-0748.pdf

expanding the use of agricultural feedstocks in AD provides a unique opportunity to align sustainable food production with renewable energy goals, as discussed in later sections.

Biogasdoneright[TM] - a Best Practice Case Study

To date, the most advanced examples of sustainable agricultural designs for food and bioenergy coproduction are being developed under the Italian Biogasdoneright[TM] initiative[27]. Under this framework, biogas production via AD is integrated within a regenerative agricultural system that promotes soil organic content, favours ecosystem services and improves economic resilience.

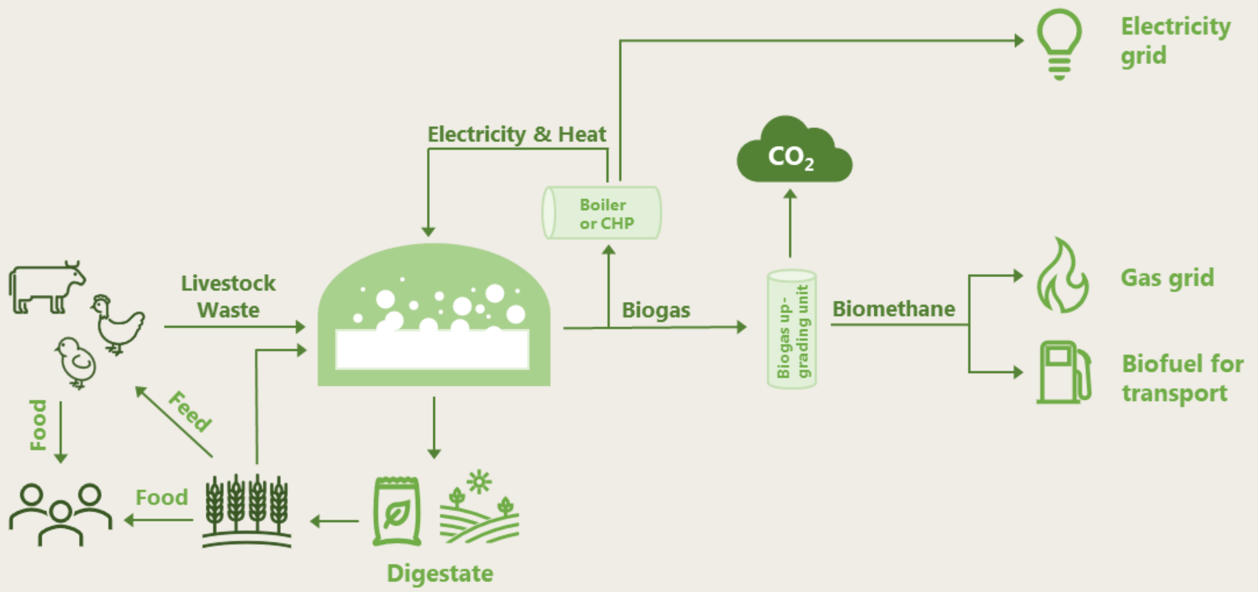


Figure 5. Illustration of the Biogasdoneright™ concept. [Adapted from ([28])]

Sequential cropping, the practice of growing multiple crops on the same land area sequentially in a growing season, is an integral part of the Italian framework as winter cover crops are used to produce feedstocks for AD without impacting food and feed production. Aside from providing viable biomethane yields and nutrient-rich digestate when processed through AD, cover crops can lead to enhanced soil nutrient content and thus, increased cash crop yields later in the season.

By adopting the Biogasdoneright model the case study of a farm in northeast Italy showed that **yields increased by 10-15%**. A modelling study of sites in Germany showed that for most crops, **yields increased by 6-14%** with the addition of cover crops in a rotation. The study also showed that the variation in yield was dependent upon the site, the nature of the cash crop grown and type of cover crop used.[29]

An increase in biodiversity is also observed as a result of not leaving fallow land and due to the multi-crop annual rotation. Quin Liu *et al*[30] conducted a meta-analysis of 76 studies and the effects of crop rotation on soil microbial indicators. They reported that crop rotation increased microbial biomass carbon and microbial biomass nitrogen by 13.43% and 15.84% respectively. In addition, the study showed an increase of 7.68% in the Shannon diversity index for soil bacteria when compared with a continuous monoculture.

---

[27] Biogasdonright: Available at: https://www.consorziobiogas.it/wp-content/uploads/2017/05/Biogasdoneright-No-VEC-Web.pdf

[28] Consorzio Italiano Biogas e Gassificazione, 2017. *Biogasdoneright. [online] Available at: https://www.consorziobiogas.it/wp-content/uploads/2017/05/Biogasdoneright-No-VEC-Web.pdf (Last* accessed August 2025)

[29] Ahmed Attia, Carsten Marohn, Ashifur Rahman Shawon, Arno de Kock, Jorn Strassemeyer, Til Feike. (2024) Do rotations with cover crops increase yield and soil organic carbon? -A modelling study in southwest Germany. Agriculture, Ecosystems and Environment. 375, 109167

[30] Qing Liu, Yingxing Zhao, Teng Li, Lin Chen, Yuanquan Chen, Peng Sui. (2023) Changes in soil microbial biomass, diversity and activity with crop rotation in cropping systems: A global synthesis. Applied Soil Ecology. 186, 104815

2.4 Future Policy Framework

A Call for Evidence on the Future Policy Framework for Biomethane Production[31] was launched by DESNZ in 2024 following the Biomass Strategy's recognition of the important role of biomethane from AD and acknowledging the pivotal role that biomethane will play in the future of the UK's energy system, delivering energy security and decarbonisation of both the energy and waste sectors. It was noted that AD plants will be expected to deliver significant volumes of biomethane under the new framework and will continue to ensure effective waste management at the same time. The aim of the Future Policy Framework is to help further incentivise the biomethane industry to scale-up and reach its full potential, whilst recognising the value of the gas grid as an enabler for growth.

The Call for Evidence sought views on strategies to develop the biomethane sector beyond the GGSS. The key criteria used to assess feedstock sustainability included those used in the Biomass Strategy, namely: cost, GHG emissions, air quality impacts, land use, and impacts on water quantity and quality. Further criteria such as impacts on biodiversity, soil contamination and impacts on recycling rate should also be considered depending on the availability of data. The framework highlights the sustainability benefits of some of key feedstocks based on the noted criteria, as set out below:

- **Food waste** - a relatively low-cost feedstock which offers carbon savings by diverting waste from landfill.
- **Cattle and pig slurries** - reduces methane emissions whilst offering carbon savings by diverting waste from storage and capturing fugitive methane.
- **Sewage sludge** - AD is a preferred waste treatment method for sewage sludge but evidence of carbon savings is lacking.
- **Crop feedstocks** - land and water use is required for cultivation but feedstock is simpler to process and can have higher biogas yields when compared to certain other waste feedstock, delivering carbon savings in many cases.

Data and modelling supporting the Biomass Strategy indicates that there is significant potential for biomethane injection to the grid through AD out to 2050. Support for AD plants has, thus far, been limited up to 250,000 MWh per year per plant aimed at encouraging geographical diversity in deployment. However, consideration is being given to the case for supporting plants over 250,000 MWh per year, given the benefits these could bring in terms of economies of scale, subject to feedstock availability. Consideration is being given to the expansion of existing AD plants and the potential to deliver biomethane at a lower cost than building new plants as a result, as well as the use of Carbon Capture, Utilisation and Storage (CCUS) technology associated with AD to further improve the carbon credentials.

Significant legacy capacity exists, supported by the Renewables Obligation (RO), FIT and/or RHI prior to GGSS being launched, with around 11 TWh of electricity generating capacity, a smaller contribution of heat via combustion (c. 4 TWh). There is around 11 TWh of biomethane capacity connected to the networks with around 7.5 TWh of biomethane flowing into the grid annually. All prior schemes offered support for a period of 20 years from the accreditation (commissioning) date, with schemes starting in 2002, 2009 and 2010 for RO, FIT and RHI respectively. CHP conversions or expansions are not currently supported by the GGSS and as a result, unsubsidised legacy capacity will start to appear in coming years and the policy intent is not for this to cease, but for this to continue making a valuable contribution to the UK energy system.

In practice, it is likely that larger AD CHP plants would either convert to biomethane injection or expand, but for smaller sites the costs of doing so may outweigh the benefits and they would therefore most likely remain to operate as CHP facilities, supplying energy for on-site or local needs.

The widespread distribution of the gas grid in the UK presents an opportunity for economic access regardless of location, scale and feedstock type in many cases. Best practice will always be to connect to the grid where possible and economical to do so; however, DESNZ does recognise a place for smaller scale AD plants particularly using wastes or manures generated on-site to produce biogas, biomethane or electricity and heat for transport or onsite use; these facilities would not typically be connected to the gas grid as their scale and location currently prevent this.

[31] Department for Energy Security and Net Zero, Future policy framework for biomethane production: call for evidence. Can be accessed at: https://www.gov.uk/government/calls-for-evidence/future-policy-framework-for-biomethane-production-call-for-evidence

Technological advances are enabling more innovative and cost-effective technologies in this space, such as modular AD systems and smaller scale or mobile upgraders, making for quicker deployment and more effective use of gas on farms or sites where waste is generated and energy demands can be matched more feasibly. Technological developments may also allow these small sites to feed into the gas network either by direct connection or virtual pipelines.

Processing livestock wastes, including manures and slurries, on farm is an effective and beneficial waste management tool, capturing fugitive methane that would otherwise be lost during storage and handling and converting this to valuable energy for on-site use. The organic matter and nutrients contained within the manure or slurry is retained in digestate which can be spread to land in the same way the original waste would be, as an organic fertiliser where there is crop and soil need which can have sustainability benefits, displacing synthetic fertiliser and increasing soil carbon. Developing a circular economy is a key government objective where AD could play an important role at both small- and large-scale.

The Biomass Strategy demonstrated a lack of coordination between various sector-specific strategies and support schemes. Although the UK has developed several frameworks designed to take the country towards Net Zero there has been a lack of a centralised biomass framework which could give an overall view of availability and sustainability, as well as biomass distribution among the various sectors.

The lack of coordination is leading to a loss of opportunities, creating an environment in which the country's decarbonisation strategy is not optimised. For instance, agricultural policies and support schemes often neglect to take the energy sector into account, missing out on a wealth of opportunities for farmers and landowners, and failing to facilitate the establishment of a strong and diverse energy feedstock supply chain which could significantly boost key energy generation technologies.

A more coherent cross-Departmental policy framework is required, to recognise and value the wider benefits. The Future Policy Framework for Biomethane Production presents an opportunity to refocus the view of biomethane, to reconsider feedstock potential and to restructure support to better align with Net Zero ambitions across energy, waste and agriculture, rather than being purely focussed on delivering increased volumes of renewable energy.

In particular, greater integration of agricultural feedstocks cultivated via rotational or sequential cropping systems offers multiple agronomic and environmental benefits, aligned with sustainable farming policy and the key principles of regenerative agriculture. These crops help protect and improve soil health, provide profitable break crop options, and support healthier, lower-carbon food production systems. Without such crop diversity, the risk of soil degradation, increased pest and disease pressures, and biodiversity loss rises, leading to higher costs and risks for farmers. Thus, expanding the use of agricultural feedstocks in AD provides a unique opportunity to align sustainable food production with renewable energy goals.

The National Farmers Union (NFU) have placed bioenergy as one of the three pillars to Achieving Net Zero Farming's 2040 Goals (2019)[32] and have stated that government bodies would need to align to give appropriate credit for GHG abatement at appropriate points in the value chain. In their response to the Call for Evidence on the Future Policy Framework for Biomethane Production (2025) the NFU[33] noted that ambitious volume targets for 2040 and/or 2050 with interim 5-year targets would encourage investor confidence and provide a clear indication to the market on the level of production required and activity needed to deliver the desired ambition.

The response focused on feedstock provision and issues with current policy which could prevent a bold target being achieved. The maximum benefit in terms of energy security, Net Zero and sustaining diverse rural employment would be obtained using a balanced combination of primary bioenergy feedstocks as well as secondary agricultural residues, which can nevertheless follow the biomass priority use principles. The large quantities of feedstock required for AD-BECCS and other end uses are likely to favour annual break crops such as hybrid rye, maize and grass or herbal leys, grown within extended and more diverse arable rotations, benefiting soil health and storing additional soil carbon through digestate return.

The NFU urged the government to avoid setting a waste feedstock threshold and being too prescriptive for the types of feedstocks used and go on to argue that AD plants that are optimised for net GHG removal would by necessity

---

[32] NFU Achieving Net Zero. [online] Available at: https://www.nfuonline.com/media/jq1b2nx5/achieving-net-zero-farming-s-2040-goal.pdf
[33] NFU response to public consultation on Future Policy Framework for Biomethane Production. [online] Available at: https://www.nfuonline.com/media/mqbkju3f/nfu-s-response-to-future-policy-framework-for-biomethane-production-consultation.pdf

minimise the land use impact through well planned agronomy and recycling crop nutrients following the example of the Biogasdoneright™ initiative discussed above. The NFU also argue for better alignment between DESNZ and Defra, to encourage more effective utilisation of digestate.

A number of factors point to the importance of biomethane in the drive to Net Zero and the need to address concerns around feedstock availability. The European Biogas Association (EBA) produced a series of fact sheets on the benefits of biogas 'Beyond Energy' which include Regenerative Agriculture, Transport, Sustainability and Industry, and demonstrate how biogas and biomethane are already contributing to the decarbonisation of a number of sectors and further expansion. In addition, uncertainty in other technologies ability to deliver the expected outputs only strengthen the case for expanding in the near, medium and longer term.

Recently a number of hydrogen projects have run into difficulties and have stalled or been cancelled according to Hydrogen Central[34]. Among others, BP have scrapped its HyGreen project in Teesside and Air Products have cancelled the Immingham green hydrogen project. These projects have faced challenges of a lack of clear policy support from government, challenges in funding the projects as well as uncertainty around demand. This uncertainty can have knock on effects, for example Northern Gas Networks cancelled a trial for heating 2,000 houses in Redcar due to lack of supply of hydrogen. Developing public understanding and buy-in can also cause problems in rollout of technology for example a similar hydrogen trial in Whitby in Cheshire was cancelled due to local objections.

Further issues are being experienced by more mature clean infrastructure projects, Hinkley point C has suffered from delays and cost overruns and is now expected to come online between 2029 and 2031. It is notable that five of the currently operating nuclear sites will reach the end of their life between 2027 and 2035. Offshore wind has also encountered problems with Orsted discontinuing the Hornsea 4 project due to increased costs and risks associated with short timelines.[35]

With these technologies potentially failing to meet targets and deliver notable contributions, it is imperative that a coherent and integrated policy framework is produced for biomethane that recognises all the benefits of the technology beyond energy and that those benefits are rewarded.

[34] Hydrogen Central: https://hydrogen-central.com/almost-one-in-five-european-hydrogen-projects-scrapped-in-2024/
[35] Orsted company announcement available at: https://orsted.com/en/company-announcement-list/2025/05/orsted-to-discontinue-the-hornsea-4-offshore-wind--143901911

Feedstock Availability

03

3. Feedstock Availability & Uses

3.1 Feedstock Availability

Domestic feedstocks hold significant potential to drive growth in the UK biomethane sector. In the near term, food waste is expected to be the primary focus, supported by policies such as GGSS and Simpler Recycling. However, over the medium to long term, agricultural feedstocks, including crops, residues, and wastes, will become increasingly important, provided they fit within sustainable farming systems and deliver benefit beyond the energy system alone.

British farming faces a shifting landscape, with subsidies decoupled from area-based payments and a transition to a greater emphasis on environmental outcomes aimed at reducing emissions, enhancing natural assets, and supporting biodiversity. Break crops and sequential or cover crops play a vital role in sustainable rotations by protecting soil during fallow periods, increasing crop diversity, and supporting wildlife and biodiversity These practices align closely with regenerative agriculture principles, enabling simultaneous production for food, feed, and energy markets, while contributing to broader environmental and biodiversity objectives as set out in Defra's Land Use Consultation earlier this year. Similar practices are also being pursued and adopted by other UK nations, aiming to achieve the same outcomes for the farming sector in the future.

Volatility in global commodity markets drives interest in more localised, resilient supply chains that offer farmers greater control over costs and returns while delivering local economic benefits.

Agriculture accounts for roughly 12% of the UK's greenhouse gas emissions [36], much of which arises from methane released during manure management and nitrous oxide from fertiliser use. The AD of livestock waste captures methane emissions and retains nutrients in digestate, which can be applied to land to reduce reliance on synthetic fertilisers and indirectly lower nitrous oxide emissions from agriculture. By making manure more manageable and sustainable, AD provides valuable benefits across multiple sectors. However, such feedstocks can only be unlocked if the wider benefits of utilisation through AD are recognised, valued and rewarded, as discussed below.

Key feedstocks considered for biomethane production in the UK are described in the following sections, with a summary of the analysed feedstocks provided in Figure 6.

[36] Defra, 2025. *Official Statistics | Agri-climate report 2024.* [online] Available at: https://www.gov.uk/government/statistics/agri-climate-report-2024/agri-climate-report-2024 (Last accessed August 2025)

Food Waste

The UK generates substantial food waste each year, but its biomethane potential is limited by low yields, high moisture content, and short shelf-life. Volumes are also expected to decline under the UK Food and Drink Pact, targeting a 50% per capita reduction by 2030. Despite mandatory separate collections rolling out from 2025 and population growth, biomethane from food waste is projected to remain around 1 TWh/year.

Agricultural Residues

The primary residue is straw, much of which is currently used for animal bedding and energy generation via combustion. With the end of the Renewable Obligation and anticipated declines in livestock numbers, a larger share of straw is likely to become available for AD. Moreover, digestate fibre from AD is being explored as a sustainable, circular bedding option, helping to avoid creating a gap in the market.

Grassland

Grass is a highly suitable feedstock for AD, offering strong dry matter yields and comparatively high biomethane output. It is widely available across the UK and can be integrated into crop rotations, contributing to soil organic carbon and overall soil health. Same applies as to straw re decline in livestock numbers.

Livestock Waste

These materials are often freely available or incur minimal cost. Very large volumes exist in the UK, with around 82 million tonnes of slurry and manure collected annually, yet only 3.5% is currently processed through AD. Most is applied direct to land, supplying valuable nutrients and organic matter. Processing it through AD retains these benefits and often enhances them. In addition, using livestock waste in AD delivers very high carbon savings, particularly given that manure management is one of the largest contributors to UK agricultural GHG emissions.

Sequential Crops

Far from displacing food production, sequential cropping enhances yields of food crops through healthier soils and reduced synthetic fertiliser needs. Sequential crops provide biomethane and nutrient-rich digestate, improve soil nutrient content, boost subsequent crop yields, and increase biodiversity by keeping land productive within a multi-crop rotation.

Processing Waste and Residues

Clean, consistent, and high-value feedstocks, well-suited to AD due to stable methane yields. Availability is expected to rise modestly as less material is diverted to animal feed, collection improves, and production in key sectors remains steady.

Rotational Crops

Rotational crops stabilise farm returns while delivering environmental and agronomic benefits. Regenerative impacts include maintaining soil cover, prolonging root presence, increasing crop diversity, and returning organic matter to the soil. With uncropped arable land averaging 262,000 ha over the last 15 years, rotational crops offer a productive use for land that might otherwise remain idle.

Landfill Gas

Landfill gas, currently mainly used for power generation, has a high climate impact, representing around 72 % of UK waste sector emissions. Near-term potential for biomethane is strong through improved capture and waste diversion, but its contribution is expected to decline by 2050 as organic waste volumes fall.

CHP Conversions

Converting AD CHP plants for biomethane grid injection is a cost-effective option, particularly as many CHPs approach the end of their subsidy, though current GGSS support does not cover these conversions.

Sewage Sludge

Low methane yields but consistently available and supported by existing AD infrastructure. Most sludge is expected to continue to be processed via AD, though microplastics and PFAS may prompt alternative treatments over time.

Figure 6. Summary of key feedstocks for UK biomethane production, highlighting key aspects such as typical availability, main uses, and relative environmental and agronomic benefits.

Rotational Crops

While there are ongoing concerns about using agricultural land to grow crops for AD, particularly regarding potential displacement of food and feed production, the UK farming system remains highly adaptable. Commodity prices are currently low, and input prices remain high, so returns from conventional crops have reached their lowest point in over a decade. Against this backdrop, exploring alternative markets such as AD is increasingly viewed as a favourable strategy, offering more stable long-term returns along with broader environmental and agronomic benefits.

AD provides a valuable opportunity to establish local supply chains aligned with regenerative agricultural practices. As farm support payments transition from area-based subsidies to incentives linked to environmental outcomes, the integration of AD crops within rotational systems is becoming increasingly relevant.

In this context, it is important to define rotational crops, which include main crops, cash crops, and break crops. These are grown by alternating different species on the same field in a planned sequence over successive years, typically forming part of a four- to seven-year rotation. A well-designed, diverse rotation can deliver multiple agronomic, economic and environmental benefits, including improved soil fertility, enhanced soil carbon, better yields, increased ground cover and erosion control, integrated pest and disease management, and a more diversified farm income.

Crops such as maize, hybrid rye, and sugar beet are among those commonly grown in the UK for AD. These are annual arable crops that can be integrated into conventional cropping rotations without requiring permanent land-use change. Table 3 presents the typical growing seasons for these and other cash crops in the UK.

Table 3. Typical crop growing seasons in the UK (common crops for AD in Italics). Light blue shading indicates the growing season, while white indicates periods when crops are out of season.

Crop name	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Spring Barley							Sowing					Harvest
Winter Barley	Sowing										Harvest	
Spring Beans	Harvest						Sowing					
Winter Beans	Sowing											Harvest
Fodder Beet		Harvest					Sowing					
Maize		Harvest						Sowing				Harvest
Spring Oats								Sowing				Harvest
Winter Oats		Sowing										Harvest
Spring Oilseed Rape							Sowing					Harvest
Winter Oilseed Rape	Sowing											Harvest
Spring Peas							Sowing					Harvest
Potatoes (early)							Sowing					Harvest
Potatoes (maincrop)		Harvest						Sowing				
Sugar Beet					Harvest		Sowing					
Spring Wheat							Sowing					Harvest
Winter Wheat		Sowing										Harvest
Wholecrop Rye		Sowing								Harvest		

(Sowing icon) = Sowing; (Harvest icon) = Harvest

Sustainable rotational cropping also contributes directly to climate targets. The Sixth and Seventh Carbon Budgets (CB6 and CB7)[12,37] both emphasise the importance of land use in reducing emissions. Rotational crops can enhance soil health, reduce fertiliser needs, and protect water quality. Furthermore, AD using rotational crops helps offset emissions from agriculture and waste, while enabling carbon-negative energy pathways, particularly when digestate is returned to land to displace synthetic fertiliser and natural pest and disease breaks are introduced through crop

[37] Climate Change Committee, 2020. *The Sixth Carbon Budget*. [online] Available at: https://www.theccc.org.uk/publication/sixth-carbon-budget/ (Last accessed June 2025)

diversity and rotational variation. This approach aligns with the UK Biomass Strategy[38], which supports greater reliance on domestic crop-derived biomass and a shift away from imports, improving national self-sufficiency and sustainability.

The UK currently has approximately six million hectares of arable land. According to Defra, around 2% of this is used annually to grow crops for bioenergy purposes[39], including AD, biofuel production, and biomass combustion, amounting to an estimated 133,000 hectares. Of this, between 75,000 and 90,000 hectares are believed to be used specifically for crop-based AD feedstocks at present, producing between 3.5 and 4 million tonnes of material per year and generating over 5 TWh of energy, including around 2.3 TWh of biomethane. Within this, maize remains the dominant AD crop: in June 2023, 73,000 hectares were grown for AD in England, a 7% increase on the previous year and accounting for around one-third of the total maize area. By contrast, roughly 60% of maize is grown as fodder for livestock. Across the UK, the total maize area reached 266,419 hectares in 2024, up 10.8% compared with 2023.[39]

In recent years, the area of uncropped arable land has shown considerable variation, averaging around 262,000 hectares over the last 15 years.[40] This land often remains unused due to rotational challenges, where harvest and subsequent planting timings do not align, and a shortage of viable shorter-season, spring-sown, or earlier-harvested crops. Maize, wholecrop rye, and fodder beet are examples of crops that can address these challenges, offering a productive use for land that might otherwise lie fallow.

This opportunity is particularly relevant in light of recent trends. In 2024, the area of uncropped arable land rose to over 616,000 hectares, nearly double the area recorded in 2023, and significantly higher than the long-term average.[40] Many farmers are reluctant to grow break crops that do not offer a market return, but AD presents a viable economic use for such crops, encouraging their adoption and helping to bring fallow land into productive use at a local level.

In addition, over one million hectares of arable land are currently used for crops that are often considered unprofitable or in some cases are deemed impractical to grow, such as beans, oilseed rape, beet, and certain horticultural produce. Some of these markets are in structural decline: oilseed rape has been affected by pesticide restrictions, beans are often low-value, and sugar beet production is limited by proximity to processing sites and their annual quotas, for example. At the same time, declining areas of second and third wheats (grown immediately after a previous wheat crop in a rotation) are being grown due to increased pest and disease pressures requiring complex and costly treatment measures. Second and subsequent wheats would be grown to feed specification as opposed to milling (food) specification as a result. Second wheats experience a significant yield reduction in many cases compared to first wheats, with typically a 15 - 50% yield reduction being seen. Higher costs, lower yields and reduced quality hamper the profitability and attractiveness of such crops, and as a result farmers are seeking more viable, sustainable alternatives to address these issues within their rotations.

Under a scenario in which 10% of the UK's arable land is allocated to the cultivation of rotational crops for AD by 2030, rising to 12% by 2050, significant contributions to biomethane production could be achieved. With the UK's current arable land area estimated at approximately 6.2 million hectares (Figure 7)[40], this would equate to around 715,000 hectares under rotational AD crops by 2030 and just over 1 million hectares by 2050.

As shown in Figure 7, a significant share of potential lies in the East of England, which accounts for over 25% of the UK's total cropped and uncropped arable land.

[38] DESNZ, 2023. *Biomass Strategy 2023.* [online] Available at: https://www.gov.uk/government/publications/biomass-strategy (Accessed June 2025)
[39] DEFRA, 2024. *Official Statistics | Bioenergy Crops in England and the UK: 2008-2023*. [online] Available at: https://www.gov.uk/government/statistics/bioenergy-crops-in-england-and-the-uk-2008-2023/bioenergy-crops-in-england-and-the-uk-2008-2023 (Last accessed June 2025)
[40] DEFRA, 2025. *Accredited official statistics | Agricultural land use in the United Kingdom.* [online] Available at: https://www.gov.uk/government/statistics/agricultural-land-use-in-the-united-kingdom (Last accessed June 2025)

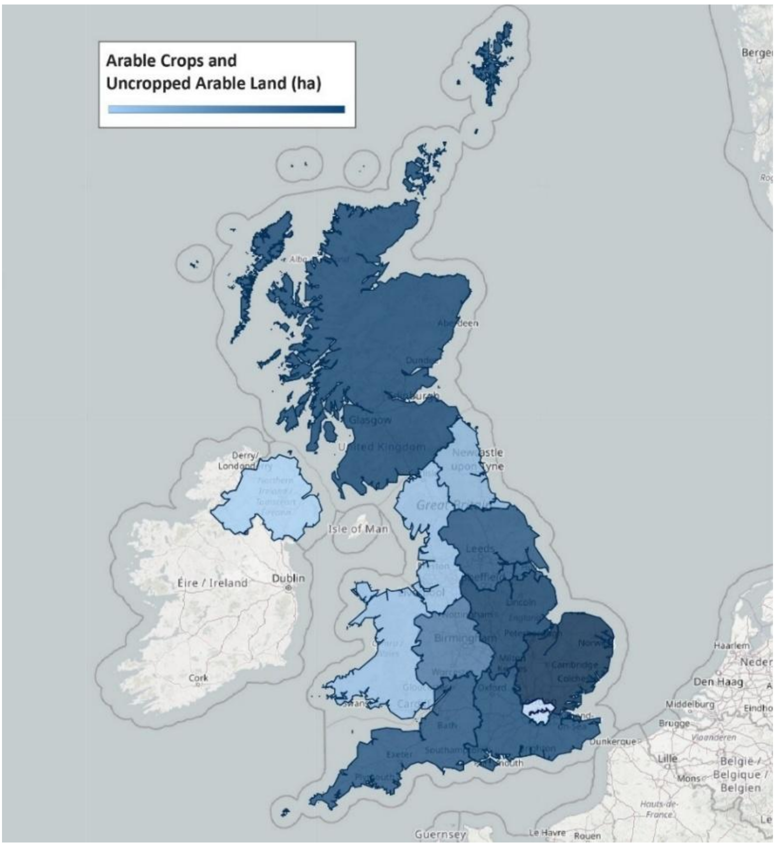


Figure 7. Heat map showing the distribution of arable land (both cropped and uncropped) across the United Kingdom, with darker blue shades indicating higher hectarage.[40]

By 2030, due to relative market maturity and based on visibility of planned processing facilities, it is expected that most of this land would be used for biogas and biomethane production, given biofuel production facilities are facing disruption and imminent closure in some cases, and new facilities will not be deployed and operational within this timeframe. However, by 2050, other bioenergy uses such as liquid biofuels may take a larger share, and it is assumed that 25% of land diverted to bioenergy crops would be allocated accordingly, with the remainder being used for AD.

Despite the changing climate, breeding programmes are expected to improve drought resilience in key UK crops[41], so yield improvements through better crop selection, soil health management, and more sustainable farming practices are still expected, with average fresh yields of wholecrop cereals projected to increase from 40 to 43 tonnes per hectare, a 7% increase in line with the Climate Change Committee's assumptions under CB7.[12] By 2050, the assumed land area could supply around 30 million tonnes of feedstock annually, supporting the production of approximately 23 TWh of biomethane by 2030, increasing to around 32 TWh by 2050.

As Government funding continues to evolve toward environmental outcomes, the strategic integration of rotational crops for AD presents a timely opportunity for farmers to diversify and stabilise income, enhance business resilience, and contribute to national climate objectives whist at the same time supporting national food and energy security objectives. Growing for more local markets provides greater opportunity to better align revenue with costs of production, as opposed to relying on global markets dictating prices for inputs and outputs as is the case for wheat and oilseeds, for example. This provides an opportunity to increase farm profitability, reducing costs, stabilising income and protecting farm businesses from global market volatility.

Having access to a local end-market (AD) largely delinked from global agricultural commodity markets presents favourable and diverse break crop options to growers who otherwise struggle to find a profitable break crop. UK growers are actively seeking alternative break crops and AD presents a stable, long-term offtake for such feedstocks. Furthermore, incorporating crops such as maize, fodder beet or wholecrop rye into a rotation can naturally break pest and disease cycles, reducing chemical costs and replenishing soil nutrients, leading to increased yields and improved

[41] The James Hutton Institute, 2025. *Hutton scientists respond to the drought facing the UK.* [online] Available at: ://www.hutton.ac.uk/hutton-scientists-respond-to-the-drought-facing-the-uk/ (Last accessed August 2025)

profitability of food and feed crops that follow in the rotation. A long-term sustainable approach of this nature Is essential for British farming, benefiting the nation, the local economy and individual farm businesses.

Sequential Crops

One opportunity to support more sustainable land management is through the use of sequential crops. Also referred to as intermediate, second, or cover crops, sequential crops involve growing two or more crops on the same field within the same year, one after the other. This typically includes a main rotational crop grown for commercial purposes, followed by a secondary crop established during the off-season, either over winter or summer.

This approach aligns closely with the principles of regenerative agriculture, which aim to improve soil health, increase carbon sequestration, enhance biodiversity, and build long-term resilience in farming systems. For example, an autumn-sown cover crop harvested in spring before a cash crop is planted can reduce soil erosion, prevent nutrient leaching, and support soil carbon levels. Similarly, summer cover crops sown between early-harvested and autumn-planted crops help retain soil moisture and provide continuous root activity. With careful planning, such rotations can offer a stable, year-round supply of feedstock suitable for AD.

Table 4 illustrates some of the most common cover and sequential crop options, along with their typical growing seasons under optimal conditions in the UK. Actual planting and harvest dates will vary with geography and the preceding and subsequent crops, so the information provided should be regarded as indicative only.

Table 4. Typical growing season requirements for example winter and spring sown sequential crops. Yellow shading indicates the growing season, while white indicates periods when crops are out of season.

Crop name	Sept	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug
Winter sown sequential crop options												
Clover			Sowing						Harvest	Good to fix N		
Lucerne	Sowing							Harvest				
Mustard		Sowing				Harvest	Not in OSR rotation; fast cover; good before cereals					
Triticale		Sowing							Harvest			
Vetch	Sowing							Harvest	Good to fix N before winter cereals			
Westerwolds (grass)	Sowing								Harvest			
Wholecrop rye	Sowing								Harvest			
Summer sown sequential crop options												
Mustard	Harvest	Not in OSR rotation, good with potatoes/sugar beet; good before winter cereals								Sowing		
Oil radish	Harvest	Not in OSR rotation, good with potatoes/sugar beet; good before winter cereals								Sowing		
Sunflower	Harvest	Ideal before winter cereals; harvest high to retain value to soil								Sowing		
Vetch	Harvest	Good to fix N before winter cereals, or OSR if harvested earlier							Sowing			
Westerwolds		Harvest	Good before winter cereals / OSR / beans						Sowing			

Sowing (symbol) = Sowing; Harvest (symbol) = Harvest

Sequential cropping also enables the co-production of food, feed, and biomethane from the same land without causing land-use displacement. When harvested for AD, these crops contribute to a renewable feedstock supply while supporting wider environmental and agronomic benefits. Importantly, this can be achieved without negatively impacting the yield of the primary crop and in many cases both quality and productivity of subsequent crops can be enhanced.

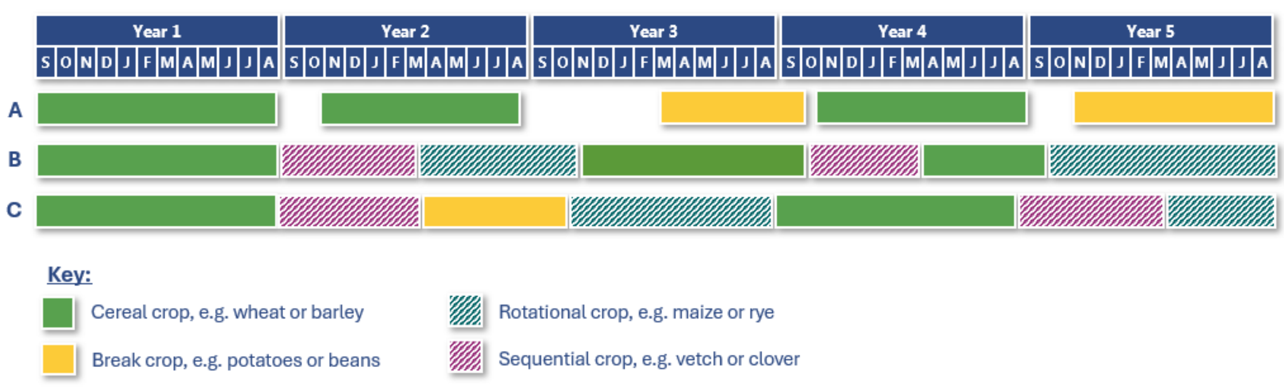
While not yet widely adopted in the UK, sequential cropping is becoming more common across Europe, particularly in France and Italy, where biomethane deployment is growing. Although the Renewable Energy Directive II (RED II) and RED III do not explicitly regulate sequential crops, they support the broader sustainability principles underpinning the practice. In the UK, financial incentives have encouraged the use of winter cover crops, notably through the Sustainable Farming Incentive (SFI) in England and similar schemes in Wales and Scotland. After the closure of the SFI scheme to new applications on 11 March 2025 a reformed version is expected following the upcoming Spending Review, likely later in 2025, with applications anticipated to reopen in 2026.[42]

In our model, assumptions from the 'Conservative Scenario' of the Magnolo *et al*. study[43] have been applied. Of the UK's 6.2 million hectares of arable land, it is estimated that 20% could be suitable for sequential cropping in both 2030 and 2050.[43] Of this area, 10% is assumed to be used for biomethane feedstock by 2030, rising to 50% by 2050. These figures reflect the potential for sequential cropping to contribute meaningfully to future biomethane supply while advancing regenerative and climate-aligned agricultural practices.

In practice this land area is deemed feasible, as considering typical UK rotations in different regions and aligned with different farm management systems, it is possible to include two sequential crops within a 5-year rotation. It is unlikely that all arable land will be suitable for sequential cropping every time it is planned within the rotation due to late harvests of preceding crops or wet periods at planning or harvest time, so tempering the target area is considered appropriate, as has been done here. Furthermore, it must be noted that this 20% of arable land is not displacing food and feed production, it is allowing an extra crop to be produced at a time that land would otherwise be left fallow or considered unproductive. This further improves the productivity of the land and the resultant profitability of UK farm businesses. Some example rotations which retain productive cereal crops, whilst incorporating sequential crops and break crops suitable for use in AD are presented below.

Sustainable Crop Rotation Examples:

Below a series of rotations are used to illustrate how crops for AD can be grown together with food crops in a rotation without impacting overall productivity, well aligned with the key principles of regenerative agriculture (*see Table 2*).



Rotation A is a conventional 5-year rotation which includes three winter-sown cereals and two break crops, comprising just three crop species in total. The Year 2 crop would be considered a *second wheat*, achieving lower yields and presenting higher pest and disease risk due to short term resistance. This second wheat would be grown for feed as opposed to milling (food) and is less attractive to growers due to reduced profitability.

Rotation B is a sustainable 5-year rotation which incorporates three cereals, two rotational crops grown for AD and two sequential crops, comprising up to five different crop species and providing soil protection year-round. The *spring-sown cereal* in Year 4 would achieve lower yields than winter-sown cereals, but would be comparable to a second wheat, as illustrated in rotation A, thus maintaining equivalent levels of food output over the rotation period.

Rotation C is an alternative sustainable 5-year rotation which includes two first wheats (cereals), a food-based break-crop (e.g. potatoes), two rotational crops grown for AD and two sequential crops, comprising up to five different crop species and providing soil protection year-round. This rotation achieves a good balance between productivity, profitability and sustainability, using the favourable traits of each species to benefit the next, and also maintains equivalent levels of food output as the more conventional system illustrated in rotation A.

It should be noted that rotations **B** and **C** effectively bring 12 otherwise unproductive months into active production, equivalent to 1 year in 5, thus **increasing the productive area by 20%** over the 5-year period.

---

[42] DEFRA, 2025. An update on the Sustainable Farming Incentive. [online] Available at: https://defrafarming.blog.gov.uk/2025/03/11/an-update-on-the-sustainable-farming-incentive/ (Last accessed June 2025)
[43] Magnolo et al., 2021. *The Role of Sequential Cropping and Biogasdoneright™ in Enhancing the Sustainability of Agricultural Systems in Europe*. Agronomy 2021, 11(**11**), 2102. https://doi.org/10.3390/agronomy11112102

Agricultural Residues

The UK produces approximately 10 million tonnes of straw annually from cereals and oilseeds primarily grown for food and feed.[40,44] Of this, around 7 million tonnes are currently used for animal bedding. According to the Biomass Strategy[38], the volume of crop residues is expected to remain relatively stable, reflecting consistent cereal and oilseed cultivation in recent decades and projected future trends.

By 2030, it is estimated that around 10.6 million tonnes of crop residues could be collectable for AD, assuming that 50% of residues will remain in the field to maintain soil health and support sustainable farming practices as is the case today. By 2050, improvements in soil management techniques and increasing volumes of digestate being available to replenish carbon stocks may reduce this requirement to 30%, increasing residue availability further. Additionally, with the Renewable Obligation for biomass power stations ending in 2032, almost 1 million tonnes of straw currently used for power generation in these facilities in the eastern regions will become available and in the longer term a reduction in livestock numbers is anticipated, further reducing demand for straw for both bedding and feed. At the same time, alternatives to straw in the bedding market are emerging, with digestate fibre from AD increasingly being explored as a sustainable option. [45]

Other crop residues, such as outgrade potatoes, vegetable waste, and beet tops, are estimated to contribute an additional 1.5 million tonnes in 2030 and around 2.0 million tonnes by 2050. Taking these into account, by 2050 up to 11 million tonnes of agricultural residues may be accessible for AD, with the potential to generate around 17 TWh of biomethane. For context, currently, approximately 0.5 million tonnes of crop residues are used to produce biomethane, generating around 0.7 TWh of energy.

Grassland

In addition to rotational arable crops, grassland presents a notable opportunity to supply feedstock for AD in the form of grass silage. Grass silage (or hay) is already widely grown, harvested and used in the UK - not only for AD, but also as forage for livestock, particularly cattle, sheep, and horses. It is considered a suitable feedstock for AD due to its strong dry matter yields and comparatively high biomethane output.

As a perennial crop, typically maintained for three years or more, grass requires less cultivation than annual crops. However, because grass is usually harvested two or three times per year, the frequency of cutting operations can lead to higher harvest-related emissions, primarily due to increased machinery use and fuel consumption.

In terms of land availability, the UK currently manages around 1.3 million hectares of temporary grassland (less than five years old) and 5.9 million hectares of permanent grassland (excluding rough grazing)[40]. Assuming an average yield of 45 tonnes per hectare per year based on two cuts from an intensively managed ley, even small proportions of this land could provide substantial feedstock volumes for AD.

As mentioned above, the UK has significant grassland coverage. As illustrated in Figure 8, England accounts for the largest share, with approximately 4.2 million hectares, followed closely by Scotland with just over 4 million hectares. Wales and Northern Ireland have around 1.5 million and 1 million hectares, respectively. Within England, the South-West has the highest concentration of grassland, with just over 1 million hectares, followed by the North-West.

---

[44] James Copeland & David Turley, 2008. *National and regional supply/demand balance for agricultural straw in Great Britain. Central Science Laboratory a study for NNFCC.* [online] Available at: https://www.researchgate.net/publication/265823113_National_and_regional_supplydemand_balance_for_agricultural_straw_in_Great_Britain (Last accessed June 2025)
[45] Stronga. *Journeying Towards Self-Reliance*. [online] Available at: https://stronga.com/en/drying-digestate-fibre-for-animal-bedding-production/ (Last accessed August 2025)

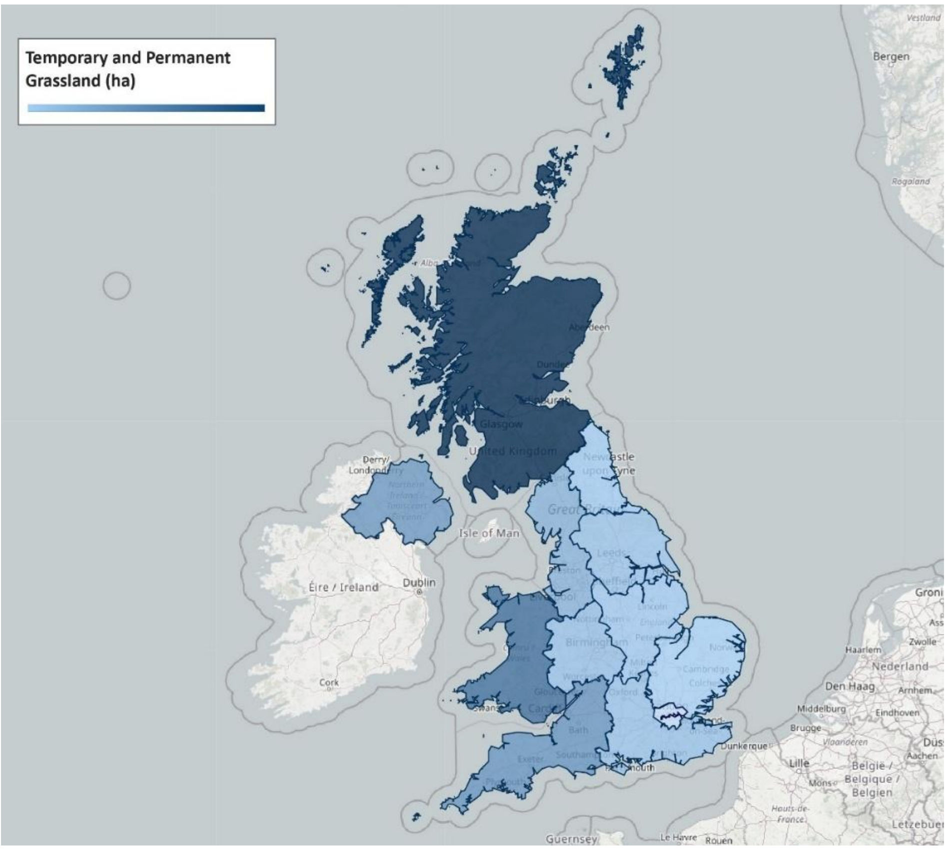


Figure 8. Heat map showing the distribution of temporary and permanent grassland across the United Kingdom, with darker blue shades indicating higher hectarage.[40]

By 2030, a conservative estimate assumes that 1% of the total UK grassland area may be diverted for silage production for AD, equating to around 3.1 TWh of biomethane. Looking ahead to 2050, the Climate Change Committee's projections for a reduction in livestock numbers and meat consumption have been considered and although deemed highly ambitious, a more modest reduction would still mean 10% of grassland could be reallocated without compromising feed availability.[12] This would correspond to a biomethane potential of approximately 33 TWh, particularly if silage harvesting is balanced with continued seasonal grazing on parts of this land.

Livestock Waste

Livestock waste encompasses both the solid and liquid components of manure and slurries produced by cattle, pigs, and poultry. Although slurry and manure typically yield lower biogas volumes compared to other feedstocks, they provide favourable biological conditions that help stabilise the AD process. These materials are often freely available or incur low costs, particularly when exchanged for digestate. Such feedstocks have played a crucial role in the growth of the AD sector across the UK and Europe, delivering significant carbon savings and increasing processing capacity. However, in the UK, past and current support schemes have prioritised food waste and rewarded on an energy basis, resulting in slurry-based systems not being widely implemented at scale.

It is estimated that the UK produces around 82 million tonnes of collectable livestock slurry and manure annually, with farmyard manure from cattle being the largest contributor, followed by cattle slurry.[46,47,48] Much of this waste is currently applied to land, supplying valuable nutrients and organic matter that reduce reliance on synthetic fertilisers. However, these benefits are retained during anaerobic digestion and the value often enhanced, as nutrients in the resulting digestate are generally more available to crops and easier to manage due to consistent production and regular testing.

[46] ADAS, 2008. *The National Inventory and Map of Livestock Manure Loadings to Agricultural Land: MANURES-GIS. Final Report for Defra Project WQ0103.* [online] Available at: https://www.data.gov.uk/dataset/6f966e56-2fac-42a9-9be9-c1529d4e5229/estimates-of-manure-volumes-by-livestock-type-and-land-use-for-england-and-wales (Last accessed June 2025)
[47] Inventory of Ammonia Emissions from UK Agriculture, 2011. *DEFRA Contract AC0112.* [online] Available at: https://uk-air.defra.gov.uk/reports/cat07/1211291427_nh3inv2011_261112_FINAL_corrected.pdf (Last accessed June 2025)
[48] Alder BioInsights. *Feedstock Database.*

Despite this potential, only about 3.5% of the collected livestock waste is currently utilised by the AD sector in the UK, primarily for biogas production via CHP to meet on-site energy demands in smaller facilities. Given the advantages of digestate and the opportunity to recover energy while reducing methane emissions, it is argued that all available livestock waste should ideally be processed through AD to deliver benefit to both energy and agriculture.

Looking ahead, given the volumes of waste being considered are all arising in livestock housing and are handled via manual or automatic systems today, it is considered practical that by 2030, 25% of collected livestock waste could be used for biomethane production, increasing to 80% by 2050. However, this will largely consist of drier farmyard manure, as it is estimated that 75% of slurry will be treated on-farm in small-scale systems producing biogas for CHP to meet local energy needs and delivering benefit direct to individual farm businesses. Given that there are few viable alternative disposal routes for collected manure, diverting this resource to biomethane production offers clear environmental and economic advantages. Despite a forecasted 38% decline in the cattle population by 2050[12], significant untapped potential remains. Taking all factors into account, livestock waste could sustainably contribute approximately 6 TWh of biomethane by 2030 and 13 TWh by 2050.

Given the availability and low current utilisation, livestock waste is expected to be a key driver for future biomethane sector growth. Biomethane derived from livestock waste is likely to have a very low carbon intensity (CI) and, when considering mitigated fugitive methane emissions from conventional manure and slurry management and combined with carbon capture and storage (CCS), this could make a substantial contribution towards the UK's greenhouse gas removal (GGR) targets.

In 2022, agriculture was a source of 12% of all greenhouse gas (GHG) emissions in the UK, broken down as 70% of all nitrous oxide emissions, 49% of all methane emissions and just 2.3% of all carbon dioxide emissions.[36] Noting the significance of nitrous oxide and methane emissions in terms of both scale and global warming potential (GWP), with these emissions coming from soil, fertiliser, grazing livestock and manure management, the potential of AD to reduce, capture and convert these emissions into useful products, to lessen the impact on the environment, becomes evident.

Food Waste

This category encompasses food waste generated by both households and businesses. Where domestic and commercial food waste is separated at source, collection is primarily managed by Local Authorities, resulting in variable availability across different regions.

While the total amount of food waste generated annually in the UK is substantial, its potential for biomethane production is limited by factors such as relatively low biomethane yields, high moisture content and the limited shelf-life of the material. Moreover, food waste volumes are expected to decline in line with the UK Food and Drink Pact (formerly the Courtauld Commitment), a UK initiative aiming for a 50% per capita reduction in food waste by 2030 compared to the 2007 baseline.[49] This target equates to approximately 45.45 kg per person, which is considered challenging to achieve.

Mandatory separate food waste collections have been introduced to non-domestic premises in England from 2025 under the Simpler Recycling policy[50], with ongoing roll-out to most households and micro-firms through to April 2026. However, despite anticipated increases in collection coverage and population growth[51], the biomethane potential from food waste is expected to remain broadly in line with current levels - around 1 TWh per year. This is largely due to delays in implementation of Simpler Recycling, with 31 local authorities having agreed transitional arrangements that further delay the introduction of separate collections between 2026 and in some cases, as late as 2043.

For this study, it is estimated that by 2030, per capita food waste will reduce to approximately 60 kg, representing a more moderate, but still significant, decrease from current levels of around 95 kg per person.[52] Also, based on research and sector knowledge around participation rates, it is further assumed that 75% of society will comply with

[49] WRAP. *UK Food and Drink Pact.* [online] Available at: https://www.wrap.ngo/take-action/uk-food-drink-pact (Last accessed June 2025)
[50] DEFRA, 2024. *Policy Paper | Simpler Recycling in England.* [online] Available at: https://www.gov.uk/government/publications/simpler-recycling-in-england-policy-update/simpler-recycling-in-england-policy-update (Accessed June 2025)
[51] ONS. *Population projections*. [online] Available at: https://www.ons.gov.uk/peoplepopulationandcommunity/populationandmigration/populationprojections (Last accessed June 2025)
[52] WRAP, 2024. *UK Food Waste & Food Surplus – Key Facts*. [online] Available at: https://www.wrap.ngo/sites/default/files/2024-01/WRAP-Food-Surplus-and-Waste-in-the-UK-Key-Facts%20November-2023.pdf (Last accessed June 2025)

food waste separation[53], with 85% of Local Authorities implementing separate food waste collections by that time. Of the waste generated, around 90% is expected to be collected. By 2050, projections suggest per capita food waste could decline further to roughly 45 kg, with an 85% compliance rate and unanimous collection by Local Authorities.

Finally, approximately 27% of the food waste currently produced is estimated to originate from commercial sources, including retail and hospitality sectors, corresponding to around 2.9 million tonnes.[52] It is anticipated that 90% of this commercial food waste will be collected by 2030 and utilised for biomethane production.

Processing Wastes and Residues

Processing wastes and residues are by-products generated during the manufacture of food and drink products. These include materials from dairies, breweries, bakeries, sugar refining, meat processing, and fruit and vegetable preparation. Produced in controlled environments, these residues are typically clean, consistent, and higher in value compared to post-consumer food waste.

These materials are particularly well-suited to AD due to their high and stable methane yields. As a result, they are in strong demand for biomethane production. At present, nearly 3 million tonnes of processing residues are treated via AD annually in the UK, with over half used for biomethane generation, corresponding to approximately 1.1 TWh of biomethane.

While the total volume of such residues is not expected to grow significantly, availability for biomethane production is projected to increase. This is driven by several factors: a likely reduction in the amount diverted to animal feed, improved separate collection of industrial food waste, and steady production levels in key sectors such as brewing and distilling, supported by population growth and sustained consumer demand. [51,54] As a result, the volume processed for biomethane production is expected to double by 2030 and triple by 2050, generating around 2.4 TWh and 4 TWh respectively.

Sewage Sludge

Wastewater treatment produces two main outputs: treated effluent (reclaimed water) and sewage sludge. To enable further processing or reuse, the sludge is typically separated into solid and liquid fractions. During the thickening stage, water is removed to increase the sludge's viscosity while maintaining its flow characteristics. The thickened sludge is then treated via AD.

Although sewage sludge delivers relatively low methane yields compared to other organic feedstocks, it benefits from consistent availability, centralised collection, and existing AD infrastructure at wastewater treatment works. In the UK, approximately 40 million tonnes of raw sewage sludge are treated annually, equivalent to around 80% of the total sludge generated. Of this, over 70% is processed via CHP facilities. The remainder, around 12 million tonnes, is treated via AD for biomethane production.[55] However, due to the high moisture content of the feedstock, this currently results in a relatively modest biomethane output of around 1.5 TWh per year.

Looking ahead, the volume of sludge treated via AD is expected to remain broadly stable by 2030 and 2050, as alternative technologies better suited to sludge, such as gasification, begin to emerge. Nonetheless, population growth is likely to lead to an overall increase in sewage sludge generation. As a result, biomethane output from sewage sludge could reach approximately 2 TWh by 2030 and 2.5 TWh by 2050, assuming continued AD deployment and optimised recovery.

However, policy developments may impact sludge management pathways. A recent report by Defra has proposed significant reductions in the land application of sewage sludge, with cuts of 50% to 95% recommended by 2030. Land

[53] While it is recognised that achieving a 75% participation rate may be challenging it is not significantly higher than rates achieved in food waste collection trials. (WRAP, 2025. *Household Food Waste Collections Guide*. Available at: https://www.wrap.ngo/sites/default/files/2025-08/WRAP-Household-Food-Waste-Guide-Aug2025-V21_0.pdf)
[54] Bell, et al., 2019. *Distillery by-products, livestock feed and bio-energy use in Scotland.* [online] Available at: https://www.gov.scot/publications/distillery-products-livestock-feed-bio-energy-use-scotland/pages/5/ (Last accessed June 2025)
[55] IEA Bioenergy, 2024. *Task 37.* [online] Available at: https://www.ieabioenergy.com/wp-content/uploads/2024/10/IEA_Bioenergy_T37_CountryReportSummary_2024.pdf (Last accessed August 2025)

spreading has traditionally followed various treatment stages and remains the main outlet for biosolids, with around 87% currently applied to agricultural land in the UK.[56]

This practice is increasingly under scrutiny due to environmental concerns, particularly regarding microplastics contamination on land. Studies show that approximately 99% of microplastics in wastewater are retained in biosolids, with only trace amounts, roughly five particles per litre, remaining in the treated effluent discharged to water bodies.[57] The accumulation of microplastics in biosolids not only raises concerns about soil contamination but may also impact AD performance by interfering with microbial activity and increasing the adsorption of pollutants. Furthermore, microplastics may degrade into nanoplastics, posing additional environmental and health risks.

Given these challenges, future sludge management may require the development and deployment of new treatment methods and technologies to ensure both regulatory compliance and environmental protection, while still enabling sustainable energy recovery.

Landfill Gas

Landfill gas is generated through the decomposition of biodegradable waste deposited in landfill sites. In modern facilities, this gas is usually captured using a network of extraction wells connected to a central collection system, where a vacuum is applied to draw the gas out. Once captured, landfill gas is typically used to generate renewable electricity on-site, which is then exported to the grid. In some cases, the gas is flared, though there is also potential for upgrading it to biomethane.

Power generation remains the dominant use of landfill gas in the UK. In 2021, landfill gas accounted for the production of approximately 3.3 TWh of renewable electricity. That same year, an estimated 0.732 tonnes of methane was captured from both operational and closed landfills, representing around 58% of total methane generated. Of this, 0.662 tonnes were used for electricity generation, 0.07 tonnes were flared, 0.054 tonnes were oxidised, and approximately 0.486 tonnes (38%) were emitted to the atmosphere.[38]

The climate implications of landfill gas are significant. In 2021, landfill emissions were estimated at 13.6 $MtCO_2e$, accounting for around 72% of total emissions from the UK waste sector.[38]

Government policy acknowledges that greater diversion of biodegradable waste from landfill, combined with improved gas capture from operational, recently closed, and legacy sites, represents one of the most effective strategies for reducing methane emissions from the waste sector. This is reflected in England's commitment to near elimination of biodegradable waste to landfill from 2028, and the ambition to eliminate food waste to landfill by 2030.

Supporting these policy goals, the Environmental Services Association (ESA) has set a methane capture target of 85% from landfill sites by 2030 as part of the Government's broader Net Zero Strategy. Landfill gas is also considered within key strategic pathways. Across the three modelled 2050 scenarios and the Carbon Budget Delivery Plan (CBDP) scenario for 2035, landfill gas, alongside other feedstocks, is prioritised for biomethane production via AD.

For this study, it is projected that, by 2030, total landfill gas volumes will decline by around 15% compared to 2021 levels, falling from 1.27 Mt to roughly 1.1 Mt. At the same time, around 30% of the landfill gas currently used for electricity generation is expected to be redirected towards biomethane production. This could yield up to 5 TWh of biomethane annually by 2030, aligning with estimates set out in the UK Biomass Strategy[38].

Looking further ahead, however, biomethane from landfill gas is not expected to play a major role in the 2050 energy mix. As landfill volumes of organic waste are projected to decline substantially, landfill gas availability, and its contribution to biomethane supply, is likely to diminish accordingly.

CHP Conversions

Converting existing AD CHP plants to biomethane injection presents a significant opportunity to increase domestic biomethane supply. Many of these facilities are nearing the end of their subsidy periods and are already equipped with core infrastructure, making them comparatively less costly to repurpose than entirely new projects.

---

[56] Assured Biosolids, 2023. *About Biosolids*. [online] Available at: https://assuredbiosolids.co.uk/about-biosolids/ (Last accessed June 2025)
[57] DEFRA, 2025. *Option Appraisal for Intentionally Added Microplastics - CB04121*. [online] Available at: https://sciencesearch.defra.gov.uk/ (Last accessed June 2025)

Currently, the Green Gas Support Scheme (GGSS) provides funding only for new biomethane plants (excluding CHP conversions) and for capacity expansions at existing GGSS-accredited sites. Although the potential for converting AD CHP plants has been widely acknowledged within the industry, particularly as existing subsidies begin to expire, the Government chose not to include such conversions within the scope of the GGSS, citing concerns around value for money. It has been suggested that this may be reconsidered as part of the forthcoming Future Biomethane Policy Framework.

Many existing CHP plants continue to receive long-term support under the Feed-in-Tariff (FIT) and Renewable Heat Incentive (RHI), which closed to new applicants in April 2019 and March 2021, respectively. Both schemes provide support for a period of 20 years from the date of accreditation. As a result, a large number of installations will see their financial support end from 2030 onwards, with most agreements concluding by 2035-2036 considering the peak growth that occurred within the coinciding accreditation period 20 years previous.

This creates a window of opportunity to convert a substantial share of this legacy capacity to biomethane injection, where grid infrastructure or access is possible and where plants are of sufficient scale to justify the additional infrastructure and investment required. While such conversions are expected to require lower capital investment than new builds, some level of financial support will still be needed, given current cost structures and market dynamics.

Based on the expiry of existing subsidy schemes and the evolving policy landscape, it is estimated that by 2030, around 20% of CHP plants could convert to biomethane injection, contributing approximately 1.6 TWh. By 2050, this share may rise to 60%, delivering around 4.7 TWh. The remaining CHP capacity is expected to consist primarily of small-scale, on-farm systems continuing to use biogas to meet on-site energy needs.

A summary of all key biomass feedstocks analysed in the sections above is presented in Table 5 and Figure 9, highlighting their potential availability in the UK by 2030 and 2050.

Table 5. Potential future availability of different biomass feedstocks in the UK, by 2030 and 2050 (TWh).

Year/ Feedstock (TWh)	2025	2030	2050
Rotational Crops	2.3	29.9	24.7
Sequential Crops	-	3.4	17.9
Agricultural Residues	0.7	6.0	16.9
Grassland	0.2	3.1	33.0
Livestock Waste	0.2	5.6	13.2
Food Waste	1.2	0.8	1.1
Processing Wastes and Residues	1.1	2.4	4.0
Sewage Sludge	1.5	1.9	2.3
Landfill Gas	-	5.0	1.0
CHP Conversions	-	2.0	5.9
Total	**7.3**	**50.0**	**120.1**

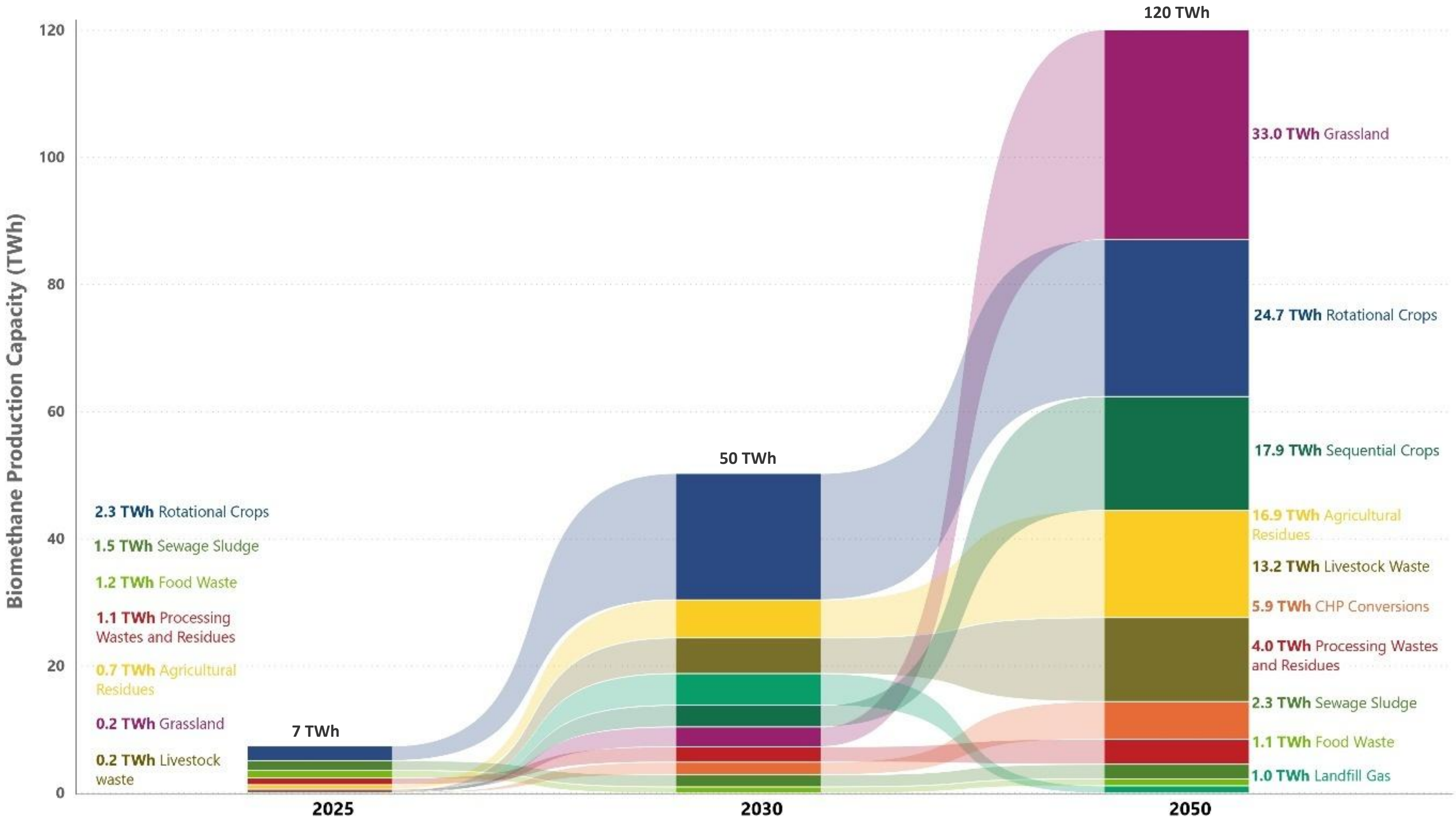


Figure 9. Potential future availability of different biomass feedstocks in the UK, by 2030 and 2050.

As shown in Figure 9, the UK has considerable resources capable of supporting the sustainable expansion of biomethane production. Untapped sustainable feedstocks could enable the production of up to 50 TWh of biomethane by 2030, rising to 120 TWh by 2050. This would represent a substantial contribution relative to current and projected future gas demand. Although biomethane presently accounts for approximately 1% of the UK's gas consumption, the 2025 Future Energy Scenarios (FES) published by the National Energy System Operator (NESO) indicate this share could rise to between 6.5% and 8.3% by 2030, depending on whether Great Britain follows the 'Falling Behind' pathway or the more ambitious 'Holistic Transition' scenario. By 2050, biomethane could meet up to 33.8% of total gas demand under more conservative projections, or potentially cover the entirety of gas demand in scenarios where electrification advances at a faster pace, reducing overall gas consumption.[14]

The most significant potential lies in grassland, and rotational and sequential cropping systems. Under the scenarios outlined in the Section 3.1, a substantial portion of arable land could be brought into productive use for AD without displacing food production or undermining land-based environmental goals.

With an estimated 6.2 million hectares of arable land in the UK[40], the modelling assumes that 10% could be allocated to rotational AD crops by 2030, rising to 12% by 2050, equivalent to 616,746 hectares by 2030 and around 740,100 hectares by 2050. These rotational crops can replace or complement existing break crops, offering benefits such as improved soil structure, pest and disease control, and enhanced biodiversity, while also generating renewable gas and delivering economic benefit at national, local and Individual farm business level.

Sequential cropping, where a secondary crop is grown between two main harvests, offers further potential. It is estimated that 20% of UK arable land could support sequential cropping in both 2030 and 2050 with no negative impact on food and feed production. When combined, these two approaches could enable more than 2 million hectares of land to contribute to biomethane production, without the need for land-use change or compromising food output.

This opportunity is particularly relevant in light of recent land-use trends. The area of uncropped arable land rose to over 616,000 hectares in 2024, nearly double the area recorded in 2023 and the longer-term average primarily driven by weather conditions in winter 2023/24.[40] This land, while classified as arable, often remains unused due to a lack of profitable break crop options. As many farmers are reluctant to grow crops that do not offer a market return, AD offers a viable economic use for break and cover crops, encouraging their adoption and helping to reintegrate fallow land into productive use at a local level.

In addition to this, over 1 million hectares of arable land is currently used for crops that are currently considered unprofitable in many cases, such as beans, oilseed rape, beet, and horticultural produce. Some of these markets are in structural decline: oilseed rape has been affected by pesticide restrictions, beans are often low value, and beet production is limited by proximity to processing sites.

As illustrated in Figure 10, a typical gross margin for rotational crops (e.g. maize, wholecrop rye) grown for AD is around £800+ so economics can be compared with key arable crops targeting more conventional markets. As input costs have increased and commodity prices have declined in recent years, profitability has been compromised in many cases as discussed above. Furthermore, second and subsequent wheats and spring-sown cereals would achieve lower yields and rely on higher inputs to tackle persistent pests and diseases, so gross margins of such crops would be lower than those illustrated, noting the chart represents first crops and winter-sown cereals only.

Also, as evident from Figure 10, gross margins for sugar beet have been relatively high recently. However, gross margins for the 2025/26 sugar beet crop are set to fall by more than 30% due to low sugar prices and persistently high variable costs, with a forecasted reduction of approximately £580/ha for a crop averaging 77 tonnes per hectare.[58]

Offering a stable and more local market through AD could strengthen the case for growing these crops, improving profitability, land use efficiency, and resilience in the farming sector.

[58] John Nix Pocketbook for Farm Management, 2025. *55th Edition | Graham Redman*. Available from: https://theandersonscentre.co.uk/publications/john-nix-farm-management-pocketbook/about-john-nix-pocketbook/

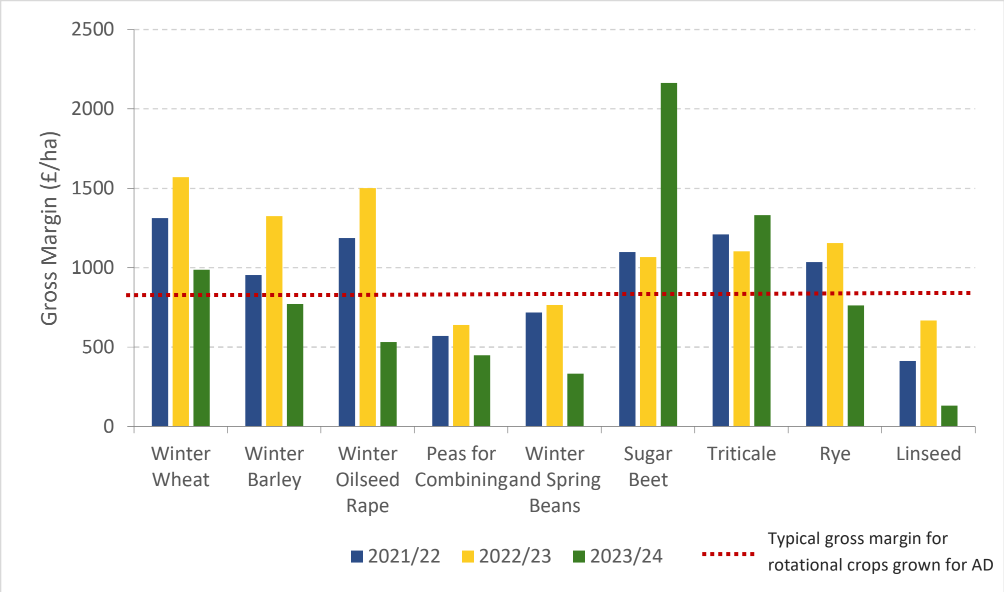


Figure 10. Gross margins for selected arable crops in England. [59]

As illustrated with the example rotations discussed earlier in the section, these practices align strongly with the principles of Regenerative Agriculture[60], as discussed in Section 2 and summarised again below:

1. Minimise soil disturbance
2. Minimise bare soil, to prevent damage and to restore nutrients
3. Maintain living roots all year-round
4. Maximise crop diversity
5. Integrate livestock, or mimic the benefits of livestock grazing using organic manure

These approaches are increasingly recognised for their role in delivering multiple environmental and agronomic benefits. A recent report by the British Ecological Society, drawing on the expertise of over 40 academics, farmers, and practitioners across the UK, has consolidated the growing body of evidence showing that regenerative agriculture can improve soil health, boost biodiversity, and minimise environmental damage - all outcomes that reinforce the case for aligning sequential and rotational cropping with regenerative principles.[61]

By supporting a shift towards more diverse and sustainable cropping systems, AD offers a route to enhance soil health, increase water retention, reduce fertiliser inputs, and strengthen climate resilience. Crops grown for AD, if managed sustainably, can help reduce the vulnerability of food production systems to drought and other climate impacts, by improving soil structure and ensuring land is not left bare, retaining moisture and delivering improved productivity elsewhere in the rotation.

Importantly, such practices can also enhance food crop yields over time. Rotational and cover crops contribute to better nutrient cycling, reduced soil compaction, and improved biological activity in the soil. By maintaining ground cover and building organic matter, they improve land resilience and productivity, making subsequent food crops more robust, more resilience to climate change impacts, and less dependent on chemical inputs. This creates a positive feedback loop in which the integration of crops grown for AD not only avoids competition with food but actively supports long-term food security.

In this context, domestic cropping should not be viewed as a trade-off with food production, but as a complementary strategy that can deliver renewable energy, lower agricultural emissions, and enhanced environmental outcomes. With the right policy environment and market signals, the biomethane sector can play a central role in bringing underutilised land into productive, regenerative use.

---

[59] Defra. *Farm Business Survey | Crop production in England.* [online] Available at: https://www.farmbusinesssurvey.co.uk/regional/Reports-on-Farming-in-the-Regions-of-England.asp (Last accessed September 2025)
[60] Royal Agricultural Society of England, 2023. *The principles of regenerative agriculture.* [online] Available at: https://www.rase.org.uk/news/the-principles-of-regenerative-agriculture/ (Last accessed July 2025)
[61] British Ecological Society, 2025. *Regenerative Agriculture in the UK | An ecological perspective.* [online] Available at: https://www.britishecologicalsociety.org/wp-content/uploads/2025/04/BES_Regenerative-agriculture-report_2025.pdf (Last accessed July 2025)

The CCC's Seventh Carbon Budget[12] takes a narrower view of feedstock availability for bioenergy applications, focussing on perennial energy crops such as miscanthus, short rotation coppice and short rotation forestry, alongside forestry residues and waste. These woody and lignocellulosic feedstocks, typically better suited to thermal or chemical conversion for power, heat or SAF, form the basis of the CCC's bioenergy assumptions. However, this approach largely sidelines annual arable crops grown in rotation or in sequence, overlooking their potential to deliver additional biomass without displacing food production and to support integrated farming and energy systems.

This approach is increasingly supported by policy. As discussed in Section 2, the UK Biomass Strategy[38] highlights the need for a balanced and resilient feedstock mix, incorporating both waste and sustainably grown crops. While waste and residue streams remain a priority, the Strategy recognises the role of integrated cropping systems in improving reliability of supply and supporting broader environmental outcomes. The development of a Future Policy Framework for Biomethane is expected to reflect these priorities by expanding the range of eligible feedstocks, improving market access, and providing the clarity needed to unlock investment in regenerative cropping models. The UK has the advantage of having a widespread gas grid which makes the full range of feedstocks considered here accessible and economically viable for biomethane production, regardless of location.

Table 6 summarises some of the wider potential impacts and risks of the feedstocks analysed in this section, drawing together implications for food production alongside agricultural and environmental benefits.

Table 6. Impact and risks from increased feedstock use for biomethane production. (Legend: [green] = positive impact; [yellow] = neutral impact; [pink] = potential negative impact)

Feedstock	Impact on food production	Improvement of soil health	GHG mitigation	Circularity potential
Rotational Crops	May displace food crops if not carefully managed but has the potential to increased yield through agronomic benefits of wider rotation.	Can improve SOC - see Section 4 for more details	See Section 4 for more details	Neutral
Sequential Crops	Can enhance subsequent food crop yields	Can improve SOC - see Section 4 for more details	See Section 4 for more details	Neutral
Agricultural Residues	Neutral	Sustainable removal is important, as excessive diversion can impact soil quality	See Section 4 for more details	Repurposed waste, but potential negative if displacing material uses such as bedding
Grassland	Neutral	Can improve SOC - see Section 4 for more details	See Section 4 for more details	Mixed (if dedicated grass grown)
Livestock Waste	Neutral	Currently spread to land. Digestate improves nutrients availability and reduces pathogens	See Section 4 for more details	Repurposed waste
Food Waste	Neutral	Neutral	See Section 4 for more details	Repurposed waste
Processing Wastes and Residues	Neutral	Neutral	See Section 4 for more details	Neutral (dependent of residue/waste)
Sewage Sludge	Neutral	Currently spread to land, concerns over release of microplastics[57]	See Section 4 for more details	Repurposed waste
Landfill Gas	Neutral	Neutral	Capturing and using LFG reduces methane emissions	Repurposed waste
CHP Conversions	Depends on feedstocks used	Depends on feedstocks used	Efficiency shift, not new savings	Depends on feedstocks used

3.2 Feedstock Uses and Competing Demands

3.2.1 Feedstock Suitability by Plant Size and Technology

The suitability of AD operating models is closely tied to the characteristics of the feedstocks involved, including their moisture content, energy yield, transportability, and seasonal availability, as well as local infrastructure, energy demand, and policy support. As such, a range of decentralised and centralised approaches have emerged across the UK, each designed to make best use of available feedstocks while maximising energy generation and ensuring economic feasibility. Decentralised models are typically located close to the source of feedstock, such as farms or food producers, reducing transport costs and enabling direct energy use. In contrast, centralised facilities aggregate larger volumes of feedstock, often from multiple suppliers, and are generally better suited for full biomethane upgrading and grid injection due to their scale. High-moisture feedstocks, particularly liquid slurries, are most economically processed on-site due to the cost and impracticality of long-distance transport. On-farm AD systems using these materials are typically smaller-scale and configured for CHP generation, where the electricity and heat are used directly on the farm, for example, to support automated milking systems, heat water, or provide space heating.

While biomethane upgrading is generally unviable at this scale due to infrastructure costs, innovative solutions are beginning to emerge. These include mobile upgrading units and localised biogas pipelines that transport raw biogas to centralised upgrading hubs. Though not yet widespread, such models offer promising potential to improve the viability of smaller-scale systems and to make remote or liquid feedstocks more accessible, particularly in UK regions with dispersed agricultural production. Reflecting this continued importance of decentralised slurry management, the scenario modelled in this report assumes that 75% of the collected slurry in the UK will continue to be treated via on-farm AD plants in both 2030 and 2050. This recognises both the logistical and environmental benefits of localised treatment of this feedstock, while allowing for innovation and gradual integration of collaborative or hybrid models where appropriate.

Medium-scale plants often co-digest mixed feedstocks, such as livestock manure, sequential crops, residues, or silage, to improve gas yields and diversify revenue streams. These systems may be operated independently or through cooperative models, where several farms contribute feedstocks or biogas to a shared upgrading and grid injection facility. In Scotland and other parts of the UK, such "virtual pipeline" arrangements are already being implemented, enabling decentralised production with centralised upgrading and injection. This model requires greater coordination and logistical oversight but offers efficiencies of scale, especially where grid access or upgrading costs would otherwise be prohibitive for individual farms.

At the upper end, large-scale centralised AD facilities handle a broader and often more energy-dense feedstock mix, including food processing residues, bakery and abattoir waste, dry manures, and crops like wholecrop rye and maize silage. These feedstocks are more easily transported and can be sourced from a wider catchment area. Such facilities are typically designed with full biogas upgrading capabilities, are often strategically sited near gas grid infrastructure, and are increasingly expected to incorporate CO_2 capture and utilisation technologies. This model is well aligned with current UK policy, which continues to support waste-based biomethane production via schemes such as the GGSS and Simpler Recycling.

3.2.2 Competing Agricultural and Local Uses

Beyond the portion of slurry already utilised in small-scale, on-farm AD plants, the majority of livestock waste in the UK currently lacks significant competing uses, representing a major underexploited opportunity for biomethane production.

The UK agricultural sector produces approximately 82 million tonnes of livestock manure and slurry each year.[46,47,48] However, only around 3.5% is currently processed through AD, with less than 1% used specifically for biomethane production. The remainder is predominantly applied directly to land as organic fertiliser. While this practice offers agronomic benefits by returning nutrients to soils, it can also present a number of environmental challenges. These include uncontrolled methane emissions during storage, ammonia volatilisation, and nitrate leaching, all of which contribute to air and water pollution, as well as climate change.

AD offers a clear pathway to address these impacts. Processing livestock waste through AD not only captures methane that would otherwise escape into the atmosphere but also retains the fertiliser value of the material in the form of digestate. In fact, digestate often presents superior agronomic benefits compared to raw manure: the nutrients, particularly nitrogen and phosphorus, are more readily available for plant uptake; pathogens are significantly reduced through the digestion process; and application rates can be more precisely managed due to routine analysis and standardised outputs. However, digestate is not without environmental risk. Its benefits depend not only on regular nutrient analysis but also on careful timing, appropriate application methods, and adherence to agronomic best practice. When managed correctly, digestate contributes to improved soil health, displaces synthetic fertilisers, and can deliver broader greenhouse gas savings across the value chain.

Agricultural residues, such as straw and vegetable outgrades, represent a significant and underutilised domestic resource for biomethane production both for small- and large-scale systems. However, their use must be considered alongside existing and evolving demands in other sectors.

One of the primary uses for cereal and oilseed straw in the UK currently is animal bedding. Of the estimated 10 million tonnes of straw collected annually, around 7 million tonnes are currently used in livestock operations, particularly in cattle systems. This represents a major draw on arable-derived biomass, and historically has limited the availability of straw for energy applications such as AD.

However, structural changes in the UK livestock sector are expected to influence this balance over the coming decades. The CCC projects a reduction in cattle and sheep numbers of approximately 37% by 2050[12], reflecting shifts in dietary preferences and climate policy alignment. As livestock numbers decline, demand for straw as bedding will fall correspondingly, potentially freeing up a greater share of arable residues for other uses, including biomethane production.

At the same time, alternative solutions are being explored that could reduce reliance on conventional straw. Digestate fibre, derived from the solid fraction of separated AD digestate, has shown potential as a sustainable bedding material. Once dried to appropriate moisture levels for bedding use, the fibre can be returned to the AD process after use,offering a circular solution.[45]

In addition, straw is currently used as a feedstock in biomass power generation. Approximately 1 million tonnes per year are directed to large-scale combustion facilities operating under the RO scheme. However, this support mechanism is due to end in 2032, at which point many of these plants are expected to cease operation unless repurposed or re-supported under alternative frameworks. This transition presents an opportunity for straw previously committed to power generation to be redirected towards higher value uses, including biomethane production via AD, which in turn would deliver greater carbon savings during energy production and additional benefits in the form of digestate, further displacing synthetic fertiliser in the farming sector.

Taken together, the phasing out of the RO scheme and projected contraction in the livestock sector could substantially increase the availability of agricultural residues for biomethane. This shift supports broader decarbonisation goals by enabling a greater share of biogenic carbon to be captured and used within the gas grid, while also reducing pressure on landfill and combustion routes. To ensure this transition occurs sustainably, policies will need to support balanced resource allocation: preserving soil health by leaving a share of residues in situ, while maximising the value of collectable materials across energy, farming, and environmental objectives.

As UK agriculture shifts away from area-based subsidies toward outcome-based environmental support, AD can support more resilient, regenerative systems. Rotational and sequential crops offer dual value: enhancing soil health and productivity, while supplying feedstock for energy production. When co-digested with manure or other residues, these crops contribute to improved nutrient recycling and emissions reductions across farming systems.

3.2.3 Cross-Sector Competition for Biomass

Alongside considerations around infrastructure, scale, and established market uses, it is also important to assess emerging pressures on biomass availability. As the UK transitions to Net Zero, competition for limited biomass resources is expected to intensify, particularly from hard-to-abate sectors such as aviation and heavy transport. This raises fundamental questions about how limited sustainable biomass resources should be prioritised. Should they be used to heat homes, an essential and often hard-to-electrify need, or to support more discretionary sectors, such as aviation, for example.

The CCC and other independent bodies have stressed the need for strategic allocation of biomass based on sustainability, carbon abatement value, and system efficiency. In its Sixth and Seventh Carbon Budgets, the CCC notes that biomass should be directed where it delivers the greatest carbon savings and cannot easily be substituted by other decarbonisation options.

Heating is a prime example. Decarbonising domestic and industrial heat remains one of the most complex challenges in the UK's transition to Net Zero. While electrification through heat pumps will become increasingly important, their deployment is still in its infancy; currently, only around 1% of UK homes are heated using a heat pump[62]. Heat pumps are not a universal solution, particularly in energy-intensive industries, and in parts of the existing housing stock, where retrofitting can be prohibitively expensive or technically unfeasible. In this context, biomethane offers one of the few scalable, immediately deployable, and cost-effective options for decarbonising heat. When injected into the gas grid, it displaces fossil methane without requiring major changes to consumer appliances or behaviours. Properties not connected to the gas network would require alternative delivery solutions and are therefore not included in this immediate deployment scenario.

The UK's extensive gas infrastructure currently supplies heat to over 20 million homes and businesses. A gradual and strategic integration of biomethane into this system enables emissions reductions from heating in the near and medium term, bridging the gap while longer-term infrastructure changes and behavioural shifts take hold. In parallel, biomethane use in high-temperature industrial processes, where electrification remains either technically or economically unviable, represents another high-value application. These are precisely the type of end uses the CCC identifies as strategic priorities for finite biomass resources, where biomethane delivers system efficiencies and carbon savings that cannot be readily achieved through other means.

Another key area where the strategic use of biomass is being actively shaped by policy is the transport sector. In the UK, support for renewable transport fuels is provided through the Renewable Transport Fuel Obligation (RTFO)[63] and, more recently, the Sustainable Aviation Fuel (SAF) Mandate[64], introduced in January 2025. The SAF Mandate sets a requirement for a minimum proportion of jet fuel supplied in the UK to come from sustainable sources, increasing incrementally to 10% by 2030. However, to ensure the environmental integrity of SAF, the mandate explicitly excludes the use of crop-based biofuels. Only fuels derived from waste and residue feedstocks are eligible, in line with the waste-based sustainability criteria defined under the RTFO.

As a result, there is no policy-driven competition between AD and SAF production for crop-based biomass. Feedstocks commonly used in AD, such as maize, wholecrop cereals, grass, and sugar beet, are not permitted to be used under the SAF Mandate. This clear regulatory separation reduces the risk of cross-sector feedstock conflict and provides medium-term clarity for AD project developers, particularly those relying on sequential or rotational cropping. Based on current policy direction and modelling scenarios, this separation could remain in place through to 2050, providing greater certainty for AD project developers and farmers.

Strategically, policy decisions around feedstock use will need to be guided not only by availability and carbon intensity, but by broader considerations of energy justice, essential service provision, and sectoral substitution potential. In comparison with other renewable energy sources, such as wind and solar, the benefits of biomethane are more wide-ranging. Wind and solar technologies provide low-cost green energy but remain intermittent and their contribution Is largely confined to power generation. Biomethane, in contrast, is complementary to these sources as it can be stored and transported to the existing gas grid, providing a reliable and dispatchable supply of energy to balance fluctuations in renewable output. The scale of energy stored and transported through the UK gas grid is considerable, accommodating daily energy swings of around 243 GWh.[65] In addition, biomethane produced via AD can deliver immediate decarbonisation in sectors with limited alternatives, while supporting rural economies, nutrient cycling, and emissions reductions from organic waste. These co-benefits reinforce the case for safeguarding AD feedstock availability in the face of emerging market and policy pressures.

Finally, rather than competing, AD can in fact enable the UK's sustainable aviation ambitions. Biomethane itself can serve as a feedstock for SAF production via thermochemical routes, including gasification and reforming Biogas upgrading to biomethane produces a high-purity stream of biogenic CO_2, a key input for emerging electrofuel (eSAF) pathways that combine captured CO_2 with green hydrogen to produce e-methane or synthetic jet fuel.

---

[62] Climate Change Committee, 2025. *Progress in reducing emissions – 2025 report to Parliament.* [online] Available at: https://www.theccc.org.uk/publication/progress-in-reducing-emissions-2025-report-to-parliament/ (Last accessed July 2025)
[63] Department for Transport, 2013. *Collection | Renewable Transport Fuel Obligation (RTFO) scheme.* [online] Available at: https://www.gov.uk/government/collections/renewable-transport-fuels-obligation-rtfo-orders (Last accessed July 2025)
[64] Department for Transport, 2024. *Collection | Sustainable Aviation Fuel (SAF) Mandate*. [online] Available at: https://www.gov.uk/government/collections/sustainable-aviation-fuel-saf-mandate (Last accessed July 2025)
[65] UK Energy Research Centre, 2020. *Flexibility in Great Britain's gas networks: analysis of linepack and linepack flexibility using hourly data.* [online] Available at: https://d2e1qxpsswcpgz.cloudfront.net/uploads/2020/03/ukerc_bn_linepack_flexibility.pdf (Last accessed September 2025)

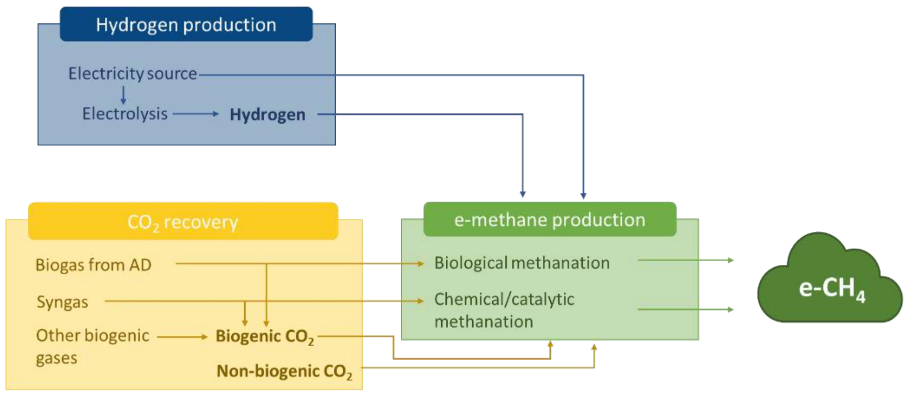


Figure 11. Key stages in the e-methane production pathway. [Adapted from (66)]

Although the production of e-methane remains limited due to current cost constraints, deployment is accelerating across Europe. According to the European Biogas Association (EBA), by the end of 2024, there were 35 operational e-methane plants in Europe, 33 of which rely entirely on renewable sources. An additional 20 facilities are either planned or under development. Out of the 55 plants identified, 47% are industrial-scale, 29% are pilot plants, 18% are demonstration-scale, and the status of the remaining 6% is unspecified. Germany leads with 14 sites, and the continent's production capacity is expected to rise from 449 GWh to nearly 3,000 GWh by 2027.[66] In this context, AD is not a competitor but a critical enabler of SAF deployment. Its dual role in supplying renewable gas and biogenic CO_2 strengthens the case for investment in AD as part of a broader, integrated low-carbon fuel infrastructure for the UK.

Beyond SAF, cross-sector competition for biomass can arise in other areas, such as the potential use of crop residues for advanced bioethanol or bio-based chemicals. While AD feedstocks like livestock waste and food waste are largely dedicated to energy recovery, other feedstocks can be directed to multiple pathways depending on market conditions and policy incentives. The main pathways are illustrated in Figure **Error! Reference source not found.**, which includes t he feedstocks analysed and presents a selection of key processes applicable to these feedstocks, followed by their main products and markets.

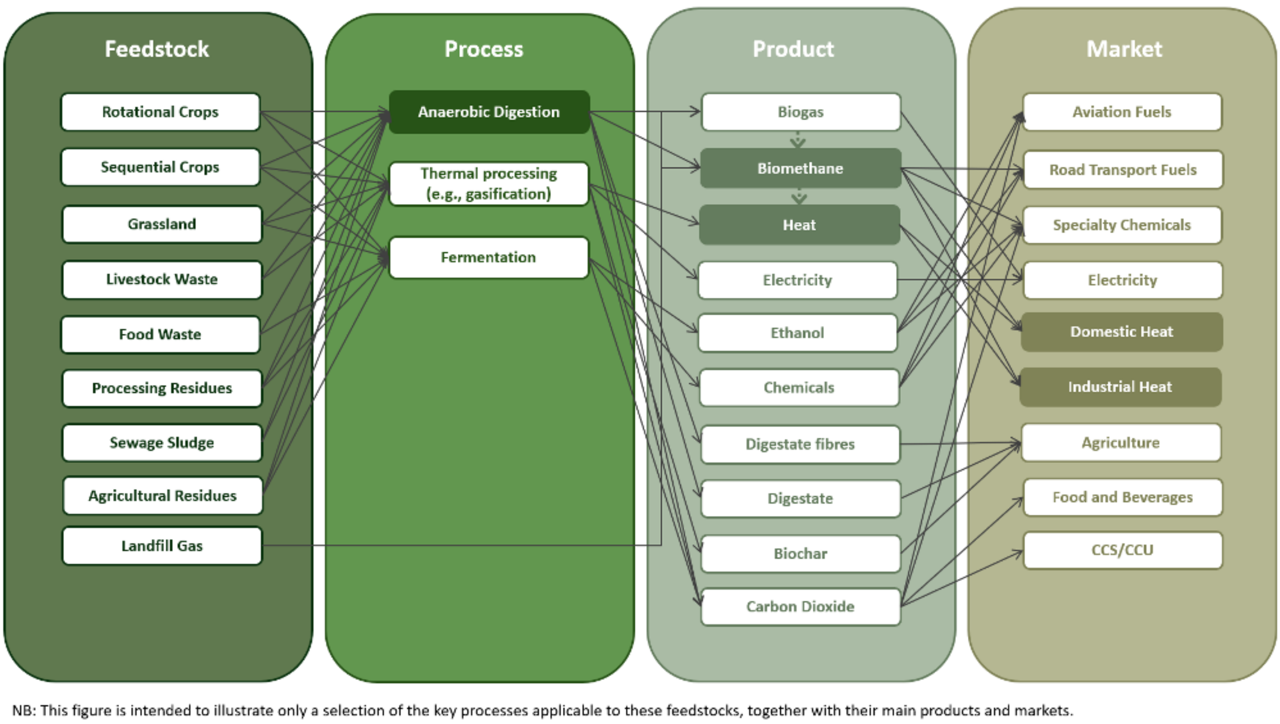


Figure 12. Overview of pathways for the analysed feedstocks in biobased products, bioenergy, and biofuel systems.

[66] European Biogas Association, 2024. *Mapping e-methane plants and technologies*. [online] Available at: https://www.europeanbiogas.eu/first-assessment-of-european-e-methane-roll-out-released-today/ (Last accessed July 2025)

Table 7. Key alternative pathways potentially competing for feedstocks assessed for biomethane production.

Feedstock	Process	Example product/s	Market	Pathway constraints and/or enablers
Rotational & Sequential Crops	Fermentation	Ethanol and other chemicals	Chemicals	Crop based chemical production is limited and small scale - without new policy support the industry is not expected to undergo significant growth.
		Ethanol	Road Transport	Demand is expected to decrease due to electrification of domestic transport. Production for this market typically focuses on wheat as the primary crop.
		Alcohol to Jet (AtJ) SAF	Air Transport	Demand expected to be limited as use not permitted under the SAF Mandate and this is expected to remain in place until 2050. This position contrasts with other regions, such as the US, where crop-based AtJ pathways are being pursued.
Agricultural Residues	Fermentation or Gasification	Ethanol and other chemicals	Chemicals	Lignocellulosic residue based chemical production is limited globally and UK chemical demand for this feedstock is not anticipated.
		Ethanol	Road Transport	Production is not established in the UK and demand is expected to decrease due to electrification of domestic transport.
		Alcohol to Jet (AtJ) / Fisher Tropsch (FT) SAF	Air Transport	The SAF Mandate could generate significant demand for agricultural residues through gasification or fermentation-based processes to produce SAF.
	Combustion	Heat	Industrial heat	The Non-Domestic RHI (NDRHI) provided 20 years of tariff support for low-carbon heat. For accredited installations, payments are grandfathered until 31 March 2041, after which many may close unless alternative support or repurposing is implemented.
		Electricity	Electricity	The Renewable Obligation (RO) is due to end in 2032, after which many large-scale straw combustion plants may close unless alternative support or repurposing is implemented.
Processing Residues	Fermentation	Ethanol and other chemicals	Chemicals	Crop based chemical production is limited and small scale - without new policy support the industry is not expected to undergo significant growth.
		Ethanol	Road Transport	Demand is expected to decrease due to electrification of domestic transport.
		SAF	Air Transport	Feedstock availability/logistics will limit production scale, negatively impacting economics and demand.
Sewage Sludge	Thermal Processing	Heat	Domestic and/or industrial heat	While AD is currently the dominant process for the treatment of sludge, gasification is an emerging technology, so competition could increase in the longer term, though it is currently at a low TRL.
		Electricity	Electricity	As above.

Table 7 summarises the main alternative pathways that could compete for the feedstocks assessed in this study for biomethane production. The table sets out the processes, products, markets, and constraints and/or enablers associated with these key pathways, focusing on those most widely discussed in policy and industry.

The role of different feedstocks varies significantly across sectors, with areas of both complementarity and competition. Rotational crops are widely used in AD, although their role is constrained by restrictions in current incentive schemes such as the GGSS. Their contribution to biofuels and bio-based chemicals is more limited, as these sectors remain at relatively low Technology Readiness Levels (TRLs) and UK and EU policies place caps on the use of crop-based biofuels. Sequential crops, while technically suitable for AD and other conversion routes, are not specifically recognised in UK policy, though international examples such as Italy's Biogasdoneright™ initiative are often cited as best practice.

Agricultural residues such as straw represent a key crossover feedstock, with potential applications in AD, advanced ethanol production, and gasification, and are eligible under the RTFO as “development fuels”. Food waste and livestock waste, by contrast, are primarily utilised in AD with little role elsewhere. This reflects their limited alternative uses, as livestock waste in particular has few viable competing pathways outside of energy recovery. Food waste remains a core AD feedstock in the UK, and while it is technically usable for advanced fuels and bio-based chemicals, commercial deployment in these sectors is still at an early stage.

Processing residues play an important but distinct role across sectors. For AD, these are largely brewery and distillery by-products, which are not the focus of SAF or road transport fuels supply chains. By contrast, SAF and road transport fuels draw heavily on used cooking oil (UCO) and tallow, which form the largest residue pool currently eligible under the SAF Mandate and RTFO. As a result, competition between AD and SAF for processing residues is considered limited. More broadly, AD should not be understood as a direct competitor with SAF for feedstocks. Aside from crops, which are excluded from the SAF Mandate, AD is better positioned as complementary to SAF deployment, providing renewable gas and biogenic CO_2 that are essential precursors for SAF and eSAF pathways.

Sewage sludge is almost exclusively used in AD, with other applications still at the R&D stage, while landfill gas, though a declining source, remains relevant for AD and occasionally features in discussions on gasification or e-fuel pathways.

Impacts and Benefits

04

4. Impacts and Benefits

Biomethane, as previously discussed, provides a highly effective means of decarbonising the UK energy system. By displacing fossil natural gas in heating and industrial applications, biomethane delivers immediate GHG reductions. In addition, when derived from waste streams and agricultural residues, it captures methane that would otherwise be released to the atmosphere, providing a dual carbon-saving effect. The utilisation of digestate, the nutrient-rich by-product of AD, further contributes to emission reductions by offsetting the need for synthetic fertilisers, which are carbon-intensive to produce. Where paired with carbon capture and storage (CCS), biomethane production can also deliver net-negative emissions, making AD a strategic enabler of the UK's long-term decarbonisation goals.

As noted earlier in this report, agriculture contributes approximately 12% of the UK's GHG emissions. In 2022, total agricultural GHG emissions were estimated at 47 $MtCO_2e$ (Figure 13), with 12% from agricultural combustion, 49% from enteric fermentation, 14% from manure management, and 24% from agricultural soils. Moreover, agriculture was responsible for 49% of the UK's total methane emissions in 2022.[36] Most of this methane originates from enteric fermentation in livestock and the anaerobic decomposition of manure. These data emphasise the need for improved manure management and more sustainable fertiliser practices to reduce emissions from livestock and soils.

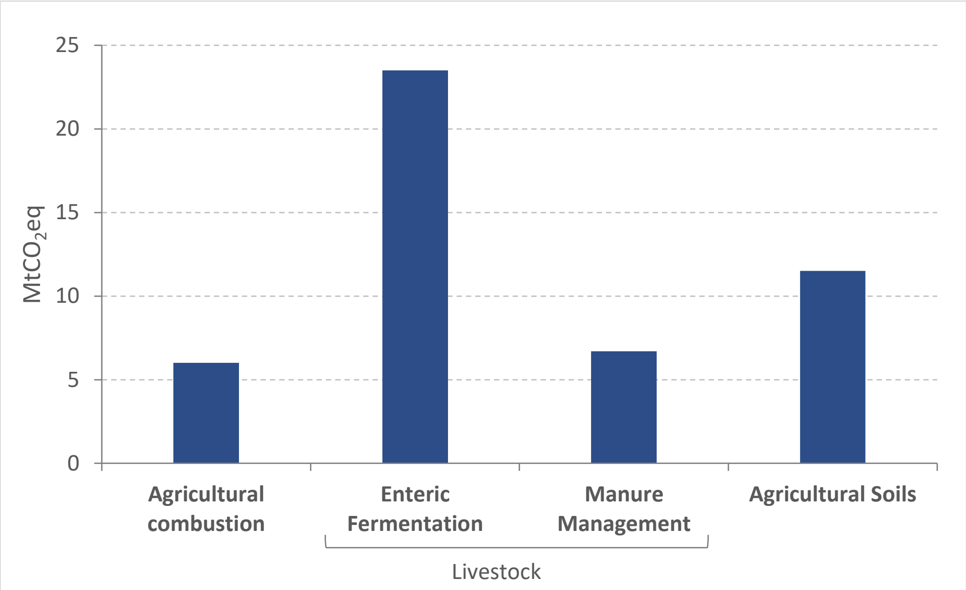


Figure 13. UK agricultural GHG emissions by source category, in $MtCO_2e$ (2022).[36]

As shown in Figure 9, the UK holds significant land potential to support the sustainable expansion of biomethane production, particularly through rotational and sequential cropping systems. Under the land-use scenarios outlined in Section 3.1, substantial areas of arable land could be brought into productive use for AD feedstocks without displacing food production or undermining land-based environmental goals. These cropping strategies allow farmers to diversify production, make use of otherwise fallow or low-value land, and integrate AD cropping alongside conventional agriculture, delivering a multitude of benefits along the way.

4.1 Carbon Benefits of Crop-Derived Biomethane

In summary, crops cultivated for AD, such as wholecrop cereals, maize, and beet, offer multiple direct carbon benefits when integrated into sustainable rotations:

- Fossil gas displacement: biomethane injected into the gas grid displaces fossil methane in heating and industrial processes, providing immediate and verifiable GHG reductions.
- Improved nutrient cycling and lower nitrous oxide emissions: digestate from crop-derived AD displaces a proportion of synthetic fertilisers, whose production is energy-intensive and emits greenhouse gases. Its more bioavailable nutrients can also reduce nitrous oxide emissions from soils compared with conventional fertiliser use.
- Negative emissions: with CCS, biogenic CO_2 from biogas upgrading can be permanently sequestered, converting AD into a net-negative emissions pathway.

In contrast, alternative biomass uses, such as the combustion of straw in power stations, offer lower system-wide benefits. While these uses displace some fossil energy and can return certain mineral nutrients to land through ash, they do not support circular nutrient cycling in the same way as AD, nor do they contribute to soil carbon improvement, or provide a balanced, bioavailable fertiliser (digestate). AD therefore offers a more integrated carbon solution, contributing to multiple decarbonisation pathways simultaneously, along with a multitude of wider system benefits as discussed below.

4.2 Wider On-Farm and System Benefits

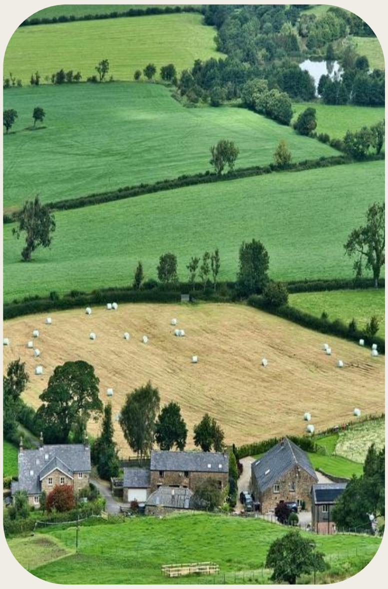
The benefits of biomethane extend beyond carbon. In summary, integrating crop-derived biomethane production into UK farming systems supports:

- Regenerative agriculture and soil health: sequential and rotational AD crops align with regenerative practices (see Sections 3.1) by maintaining ground cover, minimising soil disturbance, and enhancing biodiversity. These approaches improve soil structure, build organic matter, and increase resilience to droughts and extreme weather events.
- Enhanced food crop yields: sequential and rotational crops used in sustainable rotations can improve nutrient cycling, suppress pests and weeds, and reduce soil compaction, leading to reduced reliance on inputs and higher yields for subsequent food crops. This creates a positive feedback loop where cropping for AD supports rather than competes with food production.
- Farm profitability and economic resilience: offering a stable market for sequential and rotational crops provides new income streams for farmers, particularly for underutilised or low-value land, while reducing exposure to volatile commodity markets.
- Fertilisers and input reduction: AD digestate replaces a proportion of synthetic fertilisers, lowering emissions from both the manufacture and application of fertiliser, while reducing farm input costs over time. Even where raw manures were previously spread to land, there is no loss in nutrient value; in fact, the resulting digestate offers enhanced and safer fertilising properties. During the AD process, complex organic compounds are broken down, increasing the proportion of readily available nitrogen and improving the nutrient uptake potential for crops.

These system-wide benefits can be illustrated by practical on-farm application, such as the case of Westbrook Farm in Derbyshire, presented below.

4.2.1 Case Study: Regenerative Farming and AD at Westbrook Farm

Case Study: Regenerative Farming and AD at Westbrook Farm



Westbrook Farm is a 688-hectare family-run mixed enterprise on the southern borders of Derbyshire, managed by John Davison. The farm commissioned a 499 kWe CHP AD plant in 2016, supplying all on-site electricity and fuelled entirely by farm-produced materials.

The current rotation integrates rye as a winter cover crop followed by maize, which improves soil structure, reduces fertiliser needs, controls weeds, and enhances the productivity of key food crops such as wheat and potatoes. A proven sequence includes:

Potatoes → Wheat → Temporary Grass → Temporary Grass → Wheat → Maize → Wheat → Potatoes

Over the past 15 years, Westbrook has adopted innovative practices to strengthen soil health, resilience, and overall environmental performance.

On-Farm Circularity
The AD plant is fully fed by farm-produced materials, including chicken litter, waste potatoes, other manures, and selected crops. This closed-loop system exemplifies circularity, repurposing waste streams into renewable energy and nutrient-rich digestate, which is subsequently returned to the land to support future crop growth.

Soil regeneration
Diversified crop rotations, temporary grass leys, and cover crops have rebuilt soil health over the past 15 years, increasing organic matter, fertility, and structure while reducing reliance on synthetic inputs.

Productivity of food crops
Integrating AD and sequential cropping has enhanced the yields of key food crops such as wheat and potatoes. Far from displacing food production, this approach supports it through healthier soils and reduced fertiliser requirements.

Climate and environmental gains
The system reduces nitrous oxide emissions by substituting digestate for synthetic fertilisers, sequesters more carbon through improved soil management, and offsets methane from manures. Crop diversity and cover crops also lower nutrient leaching and improve water quality.

Farm resilience and biodiversity
More diverse crop cycles strengthen resilience to pests, diseases, and climatic stresses, while also creating habitats that support on-farm biodiversity.

Figure 14. Case Study: Westbrook Farm.

4.2.2 Biomethane Potential at Scale

When considered at scale, a transition to biomethane production supported by sustainable crop integration can deliver significant annual GHG savings across both the energy and agricultural sectors. As discussed above, it reduces methane and nitrous oxide emissions from manure and soil management while also displacing carbon-intensive synthetic fertilisers. When paired with CCS, it offers opportunities for negative emissions. At the same time, these practices enhance agricultural productivity and soil resilience, supporting long-term food security.

As highlighted above, biomethane can deliver sustainability and resilience from the farm level through to the national energy system. Its production through AD supports circular resource use, enhances energy security, and underpins the UK's decarbonisation pathway. As illustrated in Figure 15, the range of benefits spans both carbon and non-carbon outcomes, with those delivering direct carbon gains highlighted in green. Recognising and valuing these wider benefits, an approach increasingly taken in other countries, would enable more accurate reporting of the carbon intensity (CI) of biomethane, while providing stronger incentives for efficiency, improved circularity, and better use of resources.

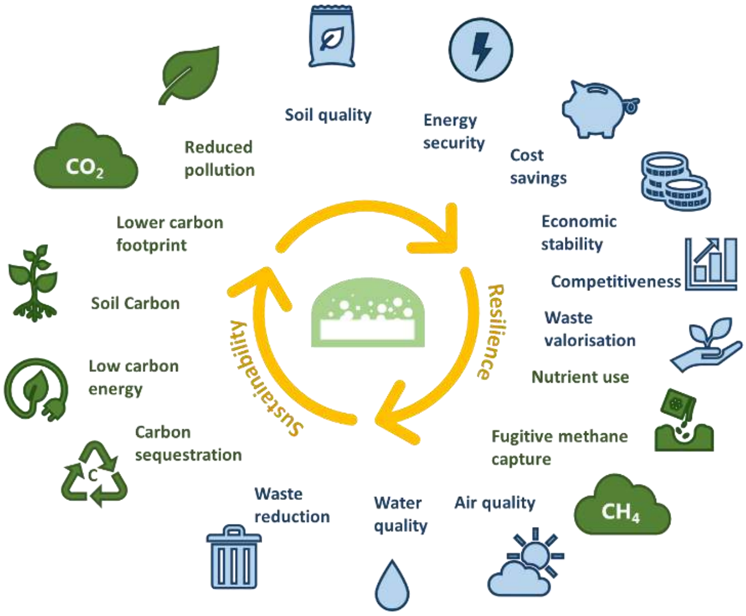


Figure 15. Infographic showing the wider benefits of biomethane production across the energy, waste and agricultural sectors.

Currently, the value of all carbon savings is captured within the energy policy framework, leaving the agricultural benefits of AD largely unrecognised. These include improved soil health, reduced synthetic fertiliser use, enhanced nutrient cycling, better slurry management, and protection of water quality through reduced nutrient runoff, as well as improved profitability and business resilience.

These benefits are critical to the long-term economic and environmental viability of the sector. Recognising them within agricultural policy would distribute the financial burden more evenly across sectors, reduce reliance on DESNZ budgets or gas consumer levies, strengthen the economic case for AD by increasing the value of digestate and potentially lowering feedstock costs, and position biomethane more competitively alongside other renewables such as wind and solar, which deliver energy without these wider co-benefits.

Recent analysis, notably the study *Beyond Energy: Monetising Biomethane's Whole-System Benefits*[67], highlights the substantial additional value biomethane production offers beyond energy supply alone. For AD, this additional benefit is estimated at approximately £72-150 per MWh of biomethane produced. These added values significantly exceed current production costs for AD biomethane, estimated between £70-78 per MWh (excluding feedstock costs)[68].

A key driver of this value is the reduction in GHG emissions, including the capture and potential utilisation of biogenic CO_2 during production. Additional benefits arise from enhanced energy security, job creation, and the processing of organic wastes. However, existing policy frameworks reward biomethane producers primarily for meeting renewable energy targets and achieving a GHG saving aligned with a conservative threshold, overlooking these broader positive externalities. For example, biogenic CO_2 utilisation could yield benefits exceeding £10 per MWh, while replacing synthetic fertilisers with digestate could contribute an additional £3-4 per MWh.[67] Benefits relating to soil health improvements remain challenging to quantify reliably with existing methodologies.

There is notable variation in these values across different feedstocks. Animal manure generates higher value due to significant reductions in fugitive emissions associated with improved manure management, contributing approximately £24 per MWh.[67] Sewage sludge presents the highest externality value, largely because of its costly organic waste processing requirements, although its relatively small share of the biomethane feedstock mix (projected at 3.5% in 2030 and 1.8% in 2050) limits its overall influence on the total valuation.

To illustrate how AD generates value across both the energy and agricultural sectors, Table 8 summarises key agricultural support mechanisms that could be aligned or adapted to better capture these wider benefits. The table

---

[67] Guidehouse & EBA, 2023. Beyond Energy: Monetising Biomethane's Whole-System Benefits. [online] Available at: https://www.europeanbiogas.eu/wp-content/uploads/2023/02/20230213_Guidehouse_EBA_Report.pdf (Last accessed August 2025)
[68] Alder BioInsights, 2025. *Biomethane costs for AD | A study for DESNZ.*

outlines current support measures, their potential integration with AD and biomethane production, and the associated co-benefits, including environmental outcomes and the above-mentioned monetised whole-system value. This framing demonstrates how a more coordinated approach to support between the energy and agricultural sectors could strengthen the economic case for AD, acknowledge the sector's contributions to emissions reduction, and ensure financial incentives are more appropriately targeted.

Table 8. Key agricultural support mechanisms, potential alignment with AD and biomethane production, and associated environmental and monetised co-benefits.

Current Agricultural Support	Potential Alignment with AD/Biomethane	Net Benefit / Co-Benefit
Subsidies/compliance costs for livestock slurry storage and spreading	AD treats slurry in a controlled process, reducing methane/ammonia emissions, generating energy.	Addresses manure management (~63% of UK agricultural GHGs); reduces methane and ammonia emissions; generates renewable energy; lowers odour and runoff; and produces digestate, a nutrient-rich by-product with improved fertilising value compared to raw livestock waste. Biomethane production additional value estimated at £24 per MWh for animal manure, reflecting reduced fugitive emissions.
Fertiliser price support or crop nutrient schemes	Incentivise digestate processing/certification to substitute synthetic fertilisers, reducing import reliance.	Supports sustainable nutrient management; helps reduce emissions from agricultural soils (~24% of UK agriculture GHGs); retains nutrients on-farm; lowers synthetic fertiliser demand. Generates £3-4 per MWh in value from fertiliser substitution.
Payments for cover crops, grass leys, and soil carbon sequestration (under the Sustainable Farming Incentive (SFI))	Encourage multi-purpose cropping: feedstock for AD plus soil/biodiversity benefits, enhancement of food yields, contribute to farm resilience.	Maintains soil carbon (~part of 24% soil emissions); supports biodiversity; provides feedstock without additional land-use pressure, economic benefit.
Environmental Land Management (ELM) payments for nutrient management, water quality improvement, emission reductions	AD provides measurable nutrient recycling and reduced runoff, supporting ELM objectives.	Improves water quality; reduces nutrient leaching; contributes to lowering emissions from manure management and soils. Captures additional system value via co-benefits like job creation and energy security.
Costs for handling crop residues, animal by-products, or organic waste	AD provides a compliant, energy-generating disposal route, reducing the need for separate subsidy support.	Diverts organic waste from landfill; generates renewable energy; reduces odour and disease risk; complements GHG reduction goals in agriculture. Monetised value of processing wastes (e.g., sewage sludge) can exceed £10 per MWh.
Grants for covered slurry stores or low emission spreading equipment	AD reduces storage requirements and improves emissions outcomes.	Cuts capital expenditure for storage; improves compliance; lowers ammonia emissions; addresses manure management emissions.
On-farm renewable energy grants (solar, wind)	AD/biomethane can be framed as integrated renewable energy generation, eligible for co-funding from both energy and agriculture budgets.	Provides predictable farm-level energy; supports energy security; contributes to reducing agricultural combustion emissions (~12% of UK agriculture GHGs). Monetised value of biomethane produced via AD is estimated at £72–150 per MWh, considerably exceeding typical production costs.

In addition to monetised co-benefits, biomethane's wider benefits and impacts are discussed below through Life Cycle Analysis (LCA), providing a fuller environmental evaluation.

4.3 Life Cycle Analysis

LCA is a systematic approach used to quantify the environmental impacts associated with all stages of a product or service life cycle. Beyond enabling industry to accurately measure and report carbon footprints, LCA helps identify opportunities for operational improvements, enhancing system performance and profitability. Current LCA methodologies aligned with REDII[3] predominantly focus on emissions from feedstock cultivation through to end use. However, they often omit important factors such as end-of-life feedstock use, the relatively minor embodied carbon within processing infrastructure, and indirect land use change arising from feedstock expansion.

Recent LCA studies have also fallen short in fully capturing the diversity of organic wastes, residues, and products utilised within UK AD systems, alongside downstream emissions linked to carbon capture and digestate management. These omissions can significantly influence estimates of carbon abatement, air quality, and ammonia emissions. Due to these methodological limitations, the broader benefits of AD remain under-recognised and consequently unrewarded.

The **system boundary** in an LCA defines which emissions are included or excluded. For AD, the system generally begins with feedstock production and ends at fuel utilisation. Biogenic CO_2 emissions are considered neutral under REDII, adopting the '0/0 approach' where uptake and release are balanced. When assessing biomethane for grid injection, the boundary ends at the injection point, while for transport applications it extends to cover transmission to and compression at refuelling stations, including Bio-CNG and Bio-LNG supply.

System boundaries may also be expanded to account for land-use change. For crops grown on arable land, no land-use change is considered; however, use of alternative land types may offer a net system benefit. Additionally, emissions avoided through the displacement of conventional manure management should be included when manure is used as an AD feedstock. Similarly, organic waste streams such as pot ale, traditionally spread on land or discharged to sea, generate fugitive methane emissions that AD can capture, thereby reducing greenhouse gases. Capturing methane from manure and other wastes not only produces renewable gas but also delivers additional sustainability benefits. Expanding the system boundary and adopting enhanced methodologies that recognise all relevant carbon savings improve accuracy and establish a foundation for targeted incentives in the future.

The treatment of digestate's end-of-life also varies depending on system boundaries. As noted earlier in this report, the use of digestate as a fertiliser displaces synthetic fertilisers, a major source of agricultural greenhouse gas emissions, providing a carbon saving which is not currently accounted for. Conversely, digestate may have a higher readily available nitrogen content than some organic alternatives like manure, further influencing emissions. Moreover, digestate contributes organic matter and supports soil microbiomes, enhancing soil health and carbon sequestration. The way in which emissions are allocated between biomethane and digestate is therefore highly consequential. Studies have shown that applying economic allocation or energy-based allocation methods can lead to notably different results for the emission intensity of biomethane. In particular, approaches that allocate emissions to digestate on the basis of calorific value may overstate the emissions attributed to biomethane. Developing accounting frameworks that better reflect the agronomic and environmental value of digestate could provide a more balanced assessment of the overall system benefits, spanning the energy, waste and agricultural sectors.[69]

When multiple feedstocks are used to produce biomethane, emissions are allocated on a mass balance basis relative to theoretical biomethane yield. Emissions can also be apportioned to co-products such as heat, electricity, or digestate, though further clarity is needed on which stakeholders claim associated emission savings.

Embodied carbon, relating to emissions from producing materials and infrastructure for AD plants, is currently excluded from REDII's biomethane emission calculations. It is common practice in LCA to exclude factors that have a low impact on the overall process, with different standards applying varying thresholds for exclusion. Previous studies have suggested that embodied carbon emissions account for less than 1% of the total emissions from AD. Consequently, it is deemed appropriate to exclude embodied emissions from LCA on this basis.

4.4 Approach

In the UK, the calculation of biomethane CI follows the principles established by REDII, reflecting the country's previous alignment with RED-based support schemes and ongoing adherence to these standards under the GGSS post-Brexit. Under this approach, emissions from wastes and residues are considered zero before collection, and emissions can be allocated to co-products according to their energy content.

REDII permits producers to apply conservative default GHG intensity values provided within the Directive or to submit actual values for their specific production pathways, following the prescribed methodology. The REDII methodology also prescribes specific adjustments: a penalty of 29 g CO_2eq/MJ is added when food and feed crops are cultivated on severely degraded land, while a credit of 45 g CO_2eq/MJ is applied when manure is digested, recognising the capture of fugitive methane emissions.

---

[69] Timonen, K. *et al.*, 2019. LCA of anaerobic digestion: Emission allocation for energy and digestate. *Journal of Cleaner Production*, 235, pp.1567-1579. https://doi.org/10.1016/j.jclepro.2019.06.085

Although REDII is widely established and implemented, certain limitations remain. Methane leakage during both digestion and upgrading processes represents a significant source of uncertainty and sensitivity within biomethane LCA methodologies. Consequently, a study by Wageningen University recommends the mandatory measurement of facility-specific methane leakage alongside the development of certification guidance to verify these measurements consistently. Additionally, the study highlights the need for a harmonised LCA methodology applicable across all feedstocks, as was acknowledged in the UK Biomass Strategy.

4.5 Results

The analysis initially considers a baseline methodology, aligned with the requirements for compliance under RED II. This baseline is then contrasted with a more comprehensive LCA approach, which incorporates additional parameters, including the allocation of benefits from digestate, the potential for carbon capture, and soil carbon accumulation.

Figure 16 presents the comparative CI of different feedstocks, considering a plant operating solely on each respective feedstock.

In the chart, the *dark blue* columns represent the baseline scenario: a RED II-compliant case without the inclusion of any additional potential benefits. These additional benefits are shown separately as striped segments: *yellow* indicates digestate handling and separation, where allocation is made by energy content (applicable only to separated digestate with measurable energy value); *green* represents captured CO_2, treated as a co-product and allocated using the substitution method; *purple* denotes soil carbon accumulation, applicable to sequential cropping and grassland systems. The *orange diamond* shows the total, net, CI when all these benefits are considered together for each feedstock. Finally, the horizontal *red dashed line* marks the current GGSS GHG emissions threshold of 24 g CO_2eq/MJ of biomethane injected. While this benchmark may not be retained in future policy frameworks, it provides a useful reference point against current regulatory requirements and given reward is currently based on meeting this threshold, with no incentive to go further, this represents a fair baseline for current mixed feedstock developments. All key modelling assumptions are provided at the end of this section.

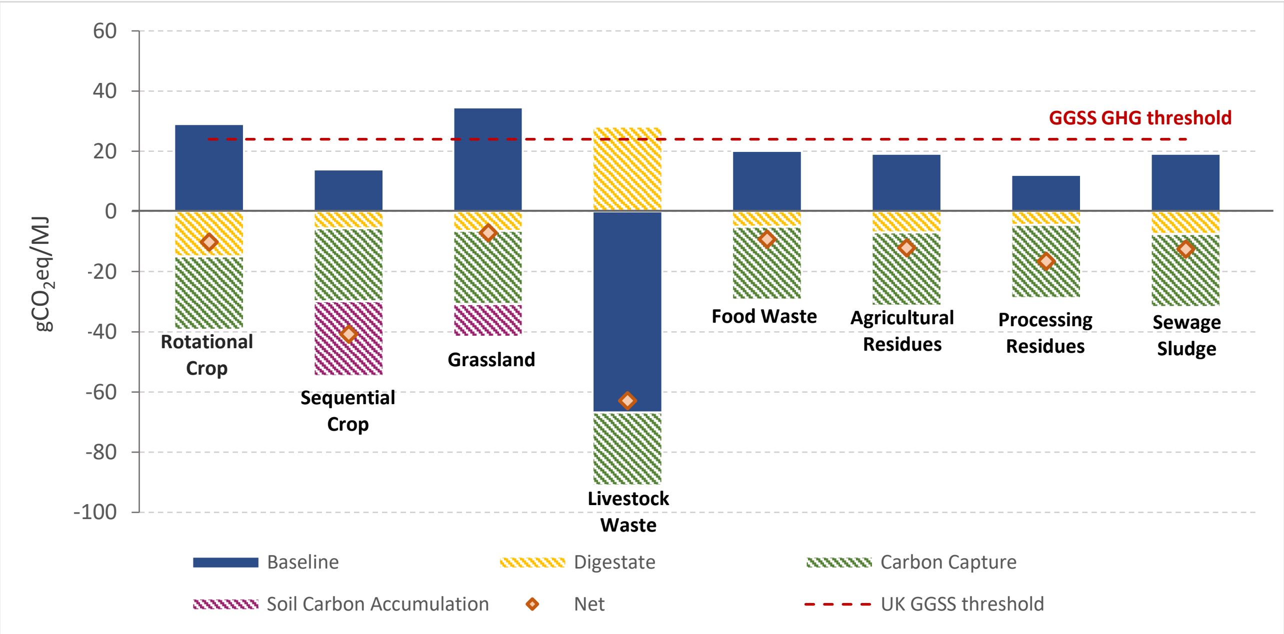


Figure 16. Comparative carbon intensity of different feedstocks, showing baseline RED II-compliant values and the additional benefits from digestate handling and separation, CO_2 capture, and soil carbon accumulation. The net total for each feedstock is shown as an orange diamond.

Among the feedstocks assessed, grassland shows the highest CI. This is largely because permanent grass systems typically involve sustained fertiliser application, leading to high upstream emissions and significant nitrous oxide release from soils. Rotational crops follow closely, with their CI primarily driven by the upstream emissions associated with cultivation, such as fertiliser and pesticide inputs, which account for approximately 40-60% of total lifecycle emissions. In this analysis, wholecrop rye has been used as the representative rotational crop, although actual values will vary by crop type and cultivation practice.

Livestock manures benefit from a substantial manure credit under RED II, while sequential cropping systems present additional soil carbon sequestration benefits. When processing residues such as spent grains are used in AD, only emissions from the point of collection are accounted for, which substantially lowers the CI of the gas generated compared to rotational crops. As a result, such residues generally perform more favourably due to their lower upstream burdens, though collection and transport emissions can still influence the overall CI.

In the baseline scenario, all digestate generated is used within the system, with all associated emissions attributed to biomethane. When emissions are allocated to digestate, the CI of all scenarios is noticeably reduced. However, it is important to note that such allocation is only possible if the digestate is separated. This is because emissions allocation is carried out on an energy basis, and wet digestate (with around 15% dry matter or less) is assumed to have no energy content. Consequently, only separated digestate with a measurable energy value can be assigned a share of the emissions.

Incorporating carbon capture within the system boundary results in a further substantial decrease in CI, quantified at -24.25 gCO_2eq/MJ biomethane. When this reduction is applied alongside the allocation of emissions to digestate, most scenarios achieve net-negative lifecycle emissions. The model assumes a methane slip of 1% from the upgrading process; however, literature indicates that when carbon capture is implemented in conjunction with AD technology, methane slip can be effectively reduced to zero in the later stages of the process.

GHG emissions for sequential crops are typically lower than for the main cash crops, as fertiliser inputs are lower; with N_2O from fertiliser application being the greatest contributing factor, the saving can be significant. Sequential cropping systems benefit further from the inclusion of soil carbon sequestration. The model assumes that cover cropping can sequester 880 kg C/ha/year[70] when the full crop biomass is incorporated into the soil leading to a CI reduction of -24.9 gCO_2eq/MJ biomethane.

Furthermore, by including sequential crops in the rotation, improving soil health and increasing soil carbon through the extensive root network, the following crops may benefit from lower fertiliser inputs, reducing N_2O emissions and bringing the overall emissions of the main crops down closer to or below the GGSS GHG threshold in some cases. The magnitude of this benefit remains highly dependent on other variables, including biogas yield and biomethane conversion efficiency.

It is important to note that digestate application can also enhance soil carbon stocks, thereby providing an additional GHG mitigation pathway which should be allocated to and rewarded by the energy or agriculture system accordingly. In the model used in this report, this effect has not been accounted for, as digestate is treated as a co-product and assigned a proportion of the plant's emissions rather than integrated into a closed nutrient cycle.

Current sustainability criteria require the inclusion of GHG emissions or removals associated with direct land-use change and prohibit sourcing feedstocks that negatively affect areas with high biodiversity value or carbon stock, such as primary forests, peatlands, and wetlands. There remains, however, an opportunity to broaden these criteria to capture the GHG benefits of utilising degraded land, enhancing soil carbon stocks more intensively, and thereby delivering greater environmental and economic gains over the longer term.

For livestock waste, as outlined in Section 4.4, RED II applies a manure credit of 45 gCO_2eq/MJ at the point of collection, which is factored into the baseline LCA. This credit reflects the avoided fugitive methane emissions from conventional manure management and results in a negative baseline CI for livestock waste. When digestate is allocated as a co-product, this allocation occurs later in the process, distributing the plant's overall emissions across multiple outputs. As a result, the share of emissions attributed to biomethane increases, thereby raising its CI. In addition, the negative emissions benefit associated with CCS is not transferred to digestate, as CO_2 capture takes place downstream, after the biogas and digestate streams have been separated. Consequently, in the case of livestock waste, allocating emissions to digestate leads to an increase in the CI assigned to biomethane; however, there is a strong case to consider and quantify the benefits elsewhere in the value chain due to the benefits seen beyond the energy system.

To illustrate the potential climate benefits of biomethane production at scale, Figure 17 presents the estimated carbon savings per feedstock based on the projected volumes available in 2030 and 2050, as detailed in Section 3.1 of

---

[70] Joshi, D.R. et al., 2023. A global meta-analysis of cover crop response on soil carbon storage within a corn production system. *Agronomy Journal,* 115(**4**). doi.org/10.1002/agj2.21340

this report. These savings are derived from the net LCA analysis described above, incorporating the full range of potential benefits, including digestate allocation, carbon capture, and soil carbon accumulation.

The chart shows total carbon savings for each feedstock, expressed in $MtCO_2e$. Across all feedstocks, based on the RED-aligned approach taken here the cumulative carbon savings are estimated at 3.2 $MtCO_2e$ per annum in 2030, rising to 8.8 $MtCO_2e$ per annum in 2050 (Figure 17), equivalent to 6.8 % and 18.8 % of 2022 UK agricultural GHG emissions[36]. This highlights the substantial role biomethane feedstocks could play in decarbonising agriculture. The greatest savings could come from livestock waste, which is particularly significant given that manure management is currently one of the largest contributors to UK agricultural greenhouse gas emissions. Substantial savings could also be achieved through sequential crops and grassland systems in the scenario analysed, demonstrating the combined potential for energy production and agricultural decarbonisation. It should be noted that the savings associated with such growth based on an enhanced LCA approach would recognise far greater full system benefits, contributing significantly towards UK greenhouse gas removals (GGR) targets.

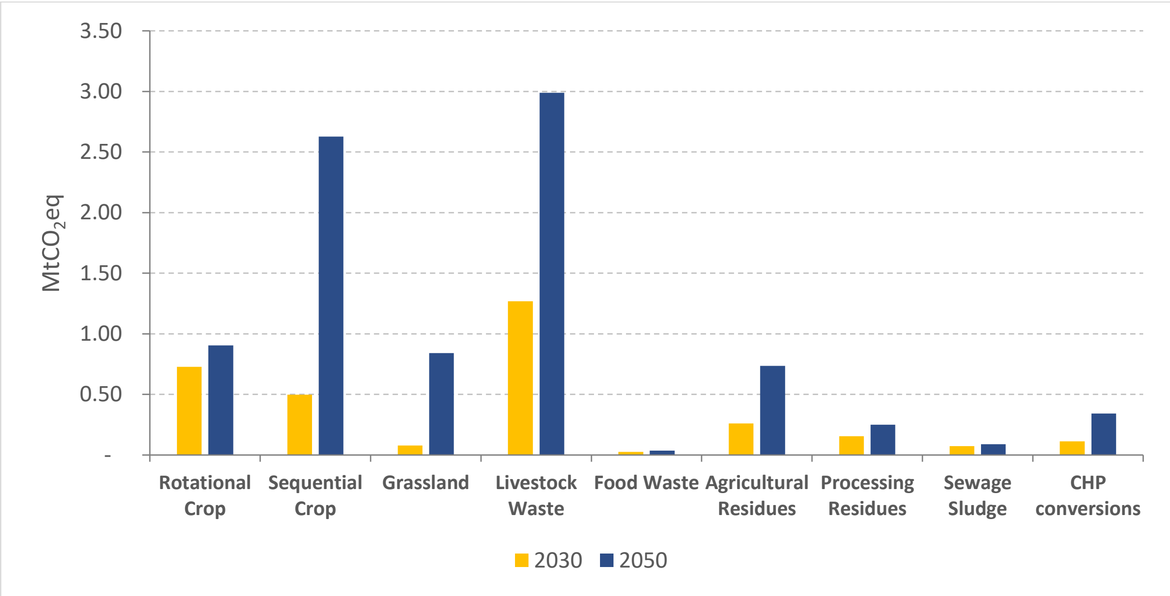


Figure 17. Carbon savings per feedstock based on the estimated biomethane potential in 2030 and 2050 in the UK, expressed in $MtCO_2e$. Savings are calculated using the net LCA approach, including digestate allocation, carbon capture, and soil carbon accumulation.

These results highlight that the strategic deployment of biomethane can make a meaningful contribution to reducing UK agricultural GHG emissions, supporting the broader Net Zero agenda while unlocking multiple environmental co-benefits across the farming sector.

Table 9. Carbon savings per feedstock based on the estimated biomethane potential in 2030 and 2050 in the UK, expressed in $MtCO_2e$. Values reflect a net LCA approach, incorporating all categories of benefits and emissions savings outlined in Section 4.1.

Year	2030					2050				
LCA category/ Feedstock ($MtCO_2e$)	Baseline	Digestate	Carbon Capture	Soil Carbon Accumulation	Comprehensive	Baseline	Digestate	Carbon Capture	Soil Carbon Accumulation	Comprehensive
Rotational Crops	-2.08	1.07	1.74	-	0.73	-2.58	1.33	2.16	-	0.90
Sequential Crops	-0.17	0.07	0.30	0.30	0.50	-0.90	0.36	1.56	1.61	2.63
Agricultural Residues	-0.41	0.15	0.52	-	0.26	-1.17	0.43	1.48	-	0.73
Grassland	-0.39	0.07	0.27	0.12	0.08	-4.11	0.77	2.88	1.29	0.84
Livestock Waste	1.35	-0.57	0.49	-	1.27	3.17	-1.34	1.15	-	2.99
Food Waste	-0.06	0.01	0.07	-	0.03	-0.08	0.02	0.10	-	0.04
Processing Wastes and Residues	-0.11	0.04	0.21	-	0.14	-0.17	0.06	0.34	-	0.24
Sewage Sludge	-0.13	0.05	0.17	-	0.09	-0.16	0.06	0.20	-	0.10
CHP Conversions	-	-	-	-	0.11	-	-	-	-	0.34
Total					**3.2**					**8.8**

* 1 TWh = 3.6 MJ

Key Assumptions
Feedstock input volumes were adapted to match the scale of production from a representative biomethane plant with a biomethane injection capacity of 775 scm/hour. The model assumes that all biogas output, after deducting parasitic energy consumption, is upgraded to biomethane. Default values are applied for cultivation and harvesting stages, including parameters such as crop yields, fertiliser and pesticide inputs. For road transport, the model assumes diesel-powered trucks by default. Values used for digestion and upgrading processes reflect typical operational performance.

Conclusions

05

5. Conclusions

Unlocking biomethane's full potential will require policy frameworks that look beyond energy output and reflect its complete environmental, agricultural, and economic contribution. Early incentive schemes, such as the FIT, RHI, and GGSS have successfully expanded production capacity, but their focus on rewarding energy generation alone does not fully align with the broader objectives of Net Zero. Future support can be more effective by linking remuneration to verified carbon savings, with higher rewards for the greatest decarbonisation impact, while also recognising the wider agricultural and environmental benefits of AD. This approach is proven elsewhere, and given such savings are readily quantifiable, it could be adopted quickly, delivering sizeable growth at pace unlike many other technologies.

The wider benefits, which remain largely unrecognised under current policy, include enhanced soil health, reduced reliance on synthetic fertilisers, improved nutrient cycling, more effective slurry management, protection of water quality through lower nutrient runoff, and increased farm profitability and business resilience. Integrating these wider contributions into policy frameworks would distribute financial support more evenly across sectors, strengthen the economic case for AD, and position biomethane more competitively alongside other renewables. Collectively, this represents a timely opportunity for the agricultural sector to develop local markets, diversify crop options, and build business resilience at a time of volatile commodity prices and high input costs, while contributing to national sustainability goals and improving both energy and food security.

Short-term growth under the current policy framework is anticipated to continue prioritising waste feedstocks, given their immediate availability and minimal behavioural change required from stakeholders. At the same time, the sector must strategically position itself for a rapid transition to more agricultural feedstocks, enabling swift adaptation under future policy frameworks to deliver the desired scale and impact by 2030. By that time, the use of agri-feedstocks is expected to expand significantly, complemented by near-term growth opportunities from plant conversions, landfill gas, and other established feedstocks that leverage existing infrastructure and stakeholder engagement.

Greater cross-government coordination is essential to realise these opportunities. Currently, policy interests and activity for AD are dispersed across multiple departments, covering energy, waste and slurry management, water quality, and air quality, without a clear central leadership - in isolation each of these benefits can be viewed as modest, but collectively the benefit is significant and unrivalled by other low carbon technologies for this reason. Appointing a Government AD Champion could unify responsibility, ensure consistent messaging, and capture the holistic benefits of AD and biomethane to build momentum. Initiatives such as the Circular Economy Taskforce[71], launched in November 2024, provide a timely vehicle to integrate biomethane's whole-system benefits into the UK's broader sustainability agenda, recognising its contributions to resource efficiency, job creation, supply chain security, emissions reduction, soil health, and sustainable agriculture.

Recognition of biomethane's strategic role in the UK's energy transition is increasingly evident. The latest Future Energy Scenarios (FES) published by NESO in July 2025[14] explicitly include biomethane as a key component for decarbonising heating and industrial sectors. NESO's deployment estimates align closely with this report's assessment, which finds that sufficient untapped sustainable feedstocks exist to produce 50 TWh of biomethane by 2030, increasing to 120 TWh by 2050. This confirms that biomethane is a scalable and versatile solution capable of supporting decarbonisation across both energy and agricultural sectors, with feedstock availability unlikely to constrain growth. The UK has the advantage of having a widespread gas grid which makes the full range of feedstocks considered here accessible and economically viable for biomethane production, regardless of location.

In addition to its energy contribution, biomethane production offers substantial climate benefits. Across all feedstocks and based on a RED-aligned approach, the cumulative carbon savings are estimated at 3.2 $MtCO_2e$ per annum in 2030, rising to 8.8 $MtCO_2eq$ per annum in 2050 with far greater full system benefits being achieved when considering an enhanced LCA approach. The greatest savings could be realised from livestock waste, reflecting its importance given that fugitive methane from manure management is one of the largest sources of UK agricultural greenhouse gas emissions. Significant savings are also expected from sequential crops and grassland systems, where soil carbon stocks are improved and synthetic inputs are low or and in many cases zero, highlighting the potential for biomethane to support both energy generation and agricultural decarbonisation simultaneously.

Despite this potential, limited long-term ambition and short-term policy cycles have constrained investment and slowed development. Clear, credible, and well-communicated targets are crucial to provide investor confidence, while

---

[71] UK Government. *Circular Economy Taskforce*. [online] Available at: https://www.gov.uk/government/groups/circular-economy-taskforce

project timelines require streamlined planning, permitting processes, improved grid connection frameworks, and support for the valorisation of co-products such as CO_2 and digestate. Positioning biomethane at the intersection of energy and agriculture policy provides a unique opportunity to unlock system-wide benefits, attract sustained investment, and establish its role as a cornerstone of the UK's Net Zero strategy.

5.1 Policy Recommendations

I. To achieve the full potential of biomethane, future policy should explicitly **integrate its agricultural, environmental, and economic co-benefits**. Support schemes should incentivise sustainable feedstock use, reward **emissions savings** beyond the immediate production boundary, and encourage scale- and site-appropriate development. Clear deployment targets through to 2030 and 2050 are essential to provide investor confidence and drive sector growth. From this analysis, it is evident that the ambition set out in the Biomass Strategy of 30-40 TWh of biomethane by 2050 can be delivered far sooner and this figure should in fact be considered an interim 2030 target, whilst a much more ambitious target for 2050 should be considered, potentially in excess of 100TWh. Growth of this magnitude at the rate required to meet these targets would deliver huge benefit within upcoming carbon budget periods, aligning with the requirements of CB6 and CB7 whilst supporting the UK on a clear pathway to Net Zero by 2050.

II. **Cross-government** leadership is needed to unify responsibilities currently dispersed across multiple departments, ensuring consistent messaging and a coordinated strategy. Leveraging initiatives such as the **Circular Economy Taskforce** can embed biomethane's benefits in broader sustainability agendas, recognising its contributions to nutrient cycling, soil health, reduced fertiliser dependency, farm resilience, and wider environmental objectives. Taking a broader view of the benefits, recognising and valuing the full potential whilst at the same time addressing key barriers to unlock this growth is essential. To deliver growth at the desired pace, attention must be focussed on **reducing development timeframes by revisiting planning, permitting and grid connection processes**. At the same time, long-term certainty and a clear vision is necessary to reduce development and investment risk.

III. Finally, **international examples** demonstrate the effectiveness of **carbon focussed, market-based incentives**. **California's Low Carbon Fuel Standard (LCFS)**, for instance, rewards fuels based on verified carbon savings rather than energy output, encouraging investment in lower carbon biomethane, improving production efficiency, and maximising emissions reductions. A similar approach in the UK could support sector growth while ensuring tangible environmental benefits, aligned not only with DESNZ policy priorities, but also with those of Defra and beyond. Crucially, this model has accelerated capacity growth elsewhere by broadening market interest beyond traditional energy sectors, making a wider range of feedstocks, including agricultural wastes, residues and crops, more commercially attractive. In the UK, such a shift could unlock major opportunities for expansion, particularly in the context of circular, low-emission farming systems.

IV. Italy's *Biogasdoneright™* initiative demonstrates how biogas production can be successfully integrated into **regenerative agricultural systems**, delivering both energy and agronomic benefits. This model combines AD with rotational and sequential cropping, enhancing soil organic matter, supporting ecosystem services, and strengthening farm resilience, while at the same time producing low-carbon energy. By contrast, while Defra has acknowledged the potential benefits of regenerative farming, it has chosen not to incentivise such practices, citing definitional challenges and insufficient evidence of public goods provision in the UK.[26] However, the Italian example provides a clear case that regenerative designs can work in practice, driving measurable environmental and economic gains. The UK could follow this lead by explicitly recognising and rewarding the agricultural co-benefits of biomethane. Incentivising regenerative approaches to biomass production, particularly through sequential cropping, would strengthen the alignment between energy and farming policy, supporting both DESNZ's decarbonisation objectives and Defra's vision for sustainable, resilient agriculture.

By implementing these recommendations, biomethane can be positioned at the intersection of energy and agriculture policy, unlocking system-wide benefits, attracting sustained investment, and supporting the UK's Net Zero ambitions. Early action to build confidence in long-term growth, coupled with a clear policy focus and recognition of wider environmental and economic co-benefits, will be essential to realising the sector's full potential.

Biocentre, York Science Park, Innovation Way, Heslington, York YO10 5NY

+44 (0) 1904 217 182 | enquiries@alderbioinsights.co.uk

alderbioinsights.co.uk

A Green Gas Future: Outlining the feedstock potential for biomethane generation.

The Green Gas Taskforce is a collaboration between thirteen of GB's largest biomethane generators, shippers and traders, all five British gas networks, and four important industry organisations. The Taskforce will be producing a series of key reports and analysis, outlining the scope for growth of biomethane in Great Britain and the significant contribution it can deliver to the decarbonisation and energy security of the country.

Green Gas TASKFORCE

info@greengastaskforce.co.uk

SGN