Future Policy Framework for Biomethane Production: Call for Evidence

Date: 25/04/24

Organisation: Environmental Biotechnology Network (EBNet), a Network in Industrial Biotechnology and Bioenergy (NIBB) funded by the Biotechnology and Biological Sciences Research Council (BBSRC)

Contact: Angela Bywater, a.m.bywater@soton.ac.uk

Introduction

The Environmental Biotechnology Network is a free-to-join network of nearly 1400 members drawn from academia, industry and government. The vast majority of members are in the UK (99%) and 70% work in academia across varied fields, including microbiology, engineering, artificial intelligence, environmental monitoring and surveillance, bioinformatics, life cycle assessment, carbon accounting and more. The Network is the successor to the Anaerobic Digestion Network which ran from 2014-2019.

Our Network is dedicated to engineering microbial systems for environmental protection, bioremediation and resource recovery. Such systems include, for example, microbes in anaerobic digestion, wastewater treatment and those that bio-degrade plastics, oil or other emerging pollutants. Our remit includes terrestrial and aquatic environmental biotechnology, organic resources and life cycle sustainability approaches to EB.

The Network's Primary Investigator (PI) is Emeritus Professor Sonia Heaven, University of Southampton and she is supported by Professor Tom Curtis, Newcastle University; Professor Fred Coulon, Cranfield University; Professor Jhuma Sadhukhan, University of Surrey; and Assistant Professor Tony Gutierrez, Heriot-Watt University. Dr Louise Byfield and Angela Bywater have co-managed the day-to-day activities of this and the previous AD Network for a little more than a decade.

Angela Bywater, the author of this document, has also worked in the field of anaerobic digestion for more than 20 years, is an ADBA Advisory Board member, and has produced work for the International Energy Agency (IEA) Task 37 (Biogas), the Royal Agricultural Society of England (RASE) and others. She co-owned an AD company for 15 years, has run her own urban household anaerobic digester for 12 years and has a particular interest in small-scale and farm AD. As primary author, this response naturally reflects those commercial and academic interests. Em Prof Heaven has reviewed this response and her input as the UK Representative of IEA Task 37, Co-investigator to the Carbon Recycling Network (a sister NIBB) and EBNet PI reflects her knowledge and experience. Therefore, this response, whilst informed by our experience of our members, may not necessarily reflect the varied views of our funders or out EBNet membership.

Call for Evidence Questions

Chapter 1: Design and scope of a new framework

1. a) Do you agree with the principles as a basis on which to develop the policy framework?

Sustainability: Sustainability principles align well with previous policy in the AD industry, particularly where purpose-grown crops are utilised. In the case of farm AD of slurries and manures, the costs of sustainable operation, (regulation and permitting costs) associated with the introduction of the technology should not be significantly more expensive or onerous than the status quo, i.e. slurry/manure storage, with venting of the unused off-gases which occurs even on covered stores. If those costs are considerably more than the status quo, then this needs to be covered by some mechanism on the income side, as farming businesses will not be able to shift to AD and thereby reduce their carbon footprint in this hard-to-abate sector.

Security/Adaptibility: Energy security should not just be focussed on biomethane production but should also be size- and site-appropriate and therefore consider heat and electricity production. If we consider an AD plant which uses primarily slurry, a useful rule of thumb is that a 1000-cow dairy farm would produce 100 kWe or equivalent and require a 1000 m3 digester running on slurry alone. Nearly 47% of dairy cattle in England are in herds of 250 animals and above, so the capture and utilisation of methane from such operations could have a significant effect on emissions, particularly where feedstocks such as chicken manure or treated local food wastes (discussed later) can be utilised. The NNFCC estimate that only 2%-3% of the UK's ~90MT of slurries and manures are currently processed through AD, so there is considerable scope to create energy, especially on these larger operations.

Many dairy farms have considerable electricity, heating and cooling requirements which electricity/heat production through CHP can meet, so such uses of biogas/biomethane should be considered as part of the energy security mix. These smaller systems are more likely to be able to utilise the CHP heat beneficially as space heating to reduce/eliminate fossil fuel heat. Additionally, many rural areas are off the gas grid and use higher carbon heating oil, so any low-carbon replacement has a commensurately greater impact in terms of carbon reduction. Farming operations are in the business of cycling carbon, so zero-carbon policies are not appropriate in this particular context.

Support of farm AD of slurries and manures as an environmentally advanced piece of farm equipment not only helps local energy security, it also supports food security, discussed in more detail below.

Commercial viability: Large biomethane systems such as those built under the GGSS have often been funded by large multi-national investment interests and indeed, as confidence in the technology has grown, older plants have been bought up in secondary market activity. This is not an attractive or feasible route for small-farm AD, which should be regarded as an advanced piece of farm equipment to support food production and provide energy recovery, nutrient recycling and slurry (pollution) treatment. Therefore, a focus solely on carbon abatement and any commensurate Life-Cycle Analysis is far too narrow a metric and immediately disregards the wider positive externalities which AD technology offers, particularly to the livestock sector. With such a narrow, carbon-focussed perspective, cost-effective utilisation of this resource (i.e. the ~90 MT of slurries/manures) becomes increasingly unlikely.

When regarded as another piece of farm equipment, an investment in AD of course has to be considered within the context of the business, just as investment in a new tractor would be considered. However, this is not the same investment perspective or language as that of large, essentially industrial AD systems, including those primarily based on crops. Whilst it is laudable and desirable to minimise impact on food prices and energy bill payers, it should be remembered that in a pure free market-driven economy, we are not paying the environmental cost of food production. Indeed, due to a combination of factors, the cost of food as a proportion of consumer income has decreased considerably (in 1957, about 33% of total household expenditure was on food; by 2017, this had dropped to about 16%). Without government intervention through some mechanism, a pure market-driven system will not help farmers to mitigate this environmental cost of food production; there needs to be some form of income. As market 'price-takers', farmers are not able to pass this cost onto their consumers.

A parallel can be drawn with the UK's current issues with sewage pollution of rivers and coastal areas: without government intervention through some mechanism, the companies will not and cannot improve the situation: indeed, they cannot make the necessary changes because such high levels of voluntary investment would not represent best shareholder value, a primary aim of any such business.

A further example of how a solely market-driven policy will not work is given with the Renewable Transport Fuel Obligation (RTFO). To our knowledge, there have been no AD plants built which rely solely on this mechanism since, without a guaranteed minimum price, a project is simply not bankable.

Compatibility: We agree that any framework should be compatible with the wider policy landscape. This is not an easy task, but in the realm of farm AD, there have been a number of missed opportunities. The most recent example has been Defra's grant funding to cover slurry stores which **specifically** excluded the capture and beneficial use of off-gases (primarily methane) – whilst (arguably) not technically AD, companies such as Bennamann have found that the methane produced from such slurry stores is considerable and can be beneficially and economically used.

Cross-policy compatibility is not easy. A too-narrow focus on carbon (and its permanent sequestration) can have unintended consequences, particularly where (bioenergy from waste) carbon capture and storage is concerned. As a principle, positive externalities as well as the value of utilising the carbon to offset fossil carbon should be hierarchically placed above that of putting into the ground as 'permanent' storage. It is perfectly possible that a life cycle analysis assessment with certain system boundaries could show that a large-scale crop digester with biomethane production and under-sea CO2 storage has a much greater carbon sequestration impact than a small farm digester creating electricity and heat for on-site use and producing CO2 to atmosphere. This, however, ignores the wider benefits of AD, as well as the practicalities of treating such geographically diffuse feedstocks which do not travel. This is not a 'one-size-fits-all' industry.

A number of industry pundits such as John Baldwin and Michael Liebreich have produced such hierarchies for hydrogen, biomethane and CO2, and there are also useful circular economy models and waste hierarchies which apply. As an aside on the mention of 'hydrogen for heating', it should be noted that hydrogen for domestic heating is nearly at the bottom of the ladder and even for industrial heating, it is only halfway up as a good use case.

Companies such as Lanzatech can biologically transform captured carbon into valuable products to replace fossil carbon in consumer goods and fuels. A policy which focuses too narrowly on BECCS (if used in the sense of 'permanent' storage) positively disadvantages such innovative companies which have world-leading research associations. The Biomass Strategy barely mentioned the platform chemicals aspect of CO2 and methane utilisation, possibly because such existing and upcoming technologies straddle both the bioenergy and industrial fossil carbon realms.

There is also a marked disconnect between research at lower Technology Readiness Levels (TRLs) and policy/regulation which can result in very slow, costly and difficult transition of innovation from the realm of research to scale-up and commercial implementation. As a principle, any policy should do its best to consider future innovation where possible.

1. b) Are there any crucial factors missing?

From a macro point of view, the principles above should, as far as possible, be **evidence-based**, they should be **flexible** and have **vision** (both in terms of long-term consistent support and of future-proofing). For example, from LCA, energetic and mass-balance aspects, the feasibility of creating hydrogen from steam methane reformation of biomethane should be evidence-based. Both academic and industrial input into the evidence base is crucial.

Innovation and research & development: As academics we see that there is often a disconnect between industrial research priorities and those funded by UK Research and Innovation (UKRI, academia's primary funding source). Industry, for example, is keen to understand and quantify emissions under the status quo versus the impact of the introduction of AD on the status quo. They wish to have information on feedstock types and feedstock processing, process optimisation (from engineering as well as microbiological perspectives), digestate processing and the effect of digestate deployment, particularly with regards to soil carbon.

Ease of **planning and permitting** should be front and centre, and biogas plants need to be recognised as key elements in mitigating climate change. Delays on this front damage investment and investor confidence at larger scales and shackle farm diversification and food security at the smaller scale. For example, an EBNet member who owns a food waste plant could begin capturing CO2 from a gas upgrading system within 12 weeks which is the delivery time for the modular kit; however, it is likely that planning permission will take many, many months, making that particular investment increasingly unlikely.

Policy must consider the various **scales of AD** such as:

1. large, essentially industrial crop-based or food waste or sewage digesters
2. local food waste going into support on-farm slurry digesters
3. on-site AD for food processors
4. small digesters as an environmentally advanced piece of farm equipment primarily for slurry handling
5. covered slurry stores, heated or unheated, mixed or unmixed, with biogas recovery and utilisation
6. community or individually-owned digesters
7. digesters supported under the RHI, FIT or RO which are coming to the end of their tariff life

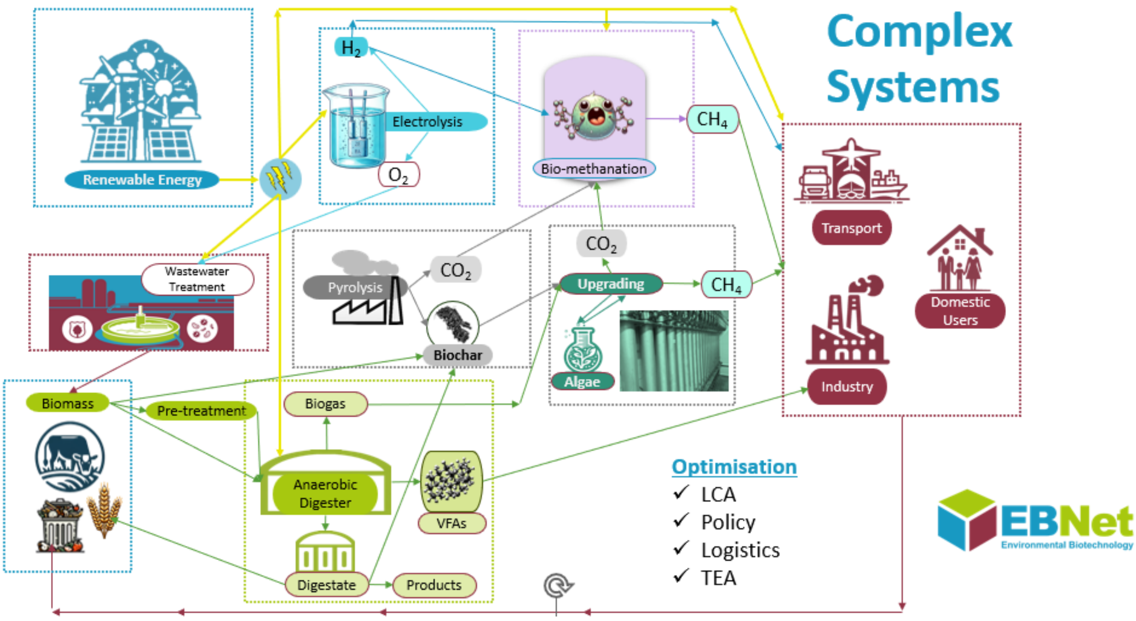
In each case, if there is any direct or indirect support, an over-riding principle is that **support should be associated with a particular scale/policy aim**. For example, under the direct support mechanism of the FIT, there would be (say) 2 MWe capacity before degression kicked in. A single 2 MWe AD plant would apply at FIT level x, thereby earmarking the budget, using the capacity in the band and causing a degression reduction. A 100 kWe plant which may have been marginal at FIT level x would have no chance of being built at the degressed level. However, if the budget for some of the capacity would have been specifically earmarked for the 100 kWe scale of plant, it could very well have been built.

It is clear that the policy mechanisms which might support the above examples could very well look quite different from each other.

2. Are there any other important current or future barriers to market growth not mentioned in Chapter 1 and what actions could the government or industry take to address them? Please provide supporting evidence, including any that highlights the scale of the impact.

The GGSS has a narrow remit which essentially focuses on larger plants which inject biomethane into the gas grid. Without its extension from 4 to 5 years, it certainly would not have reached its expected aim of ‘heating 200,000 homes’, since reported figures after a little more than 2 years after the scheme had opened showed only 1 registered participant and 11 tariff guarantees granted from 35 applications. Any policy which supports plants of this size needs to be **long-term enough** to provide investor confidence, particularly where long and expensive planning and permitting timelines are necessary for such large and complex projects.

Integration with the hydrogen economy (CO2 biomethanisation) and **Power to X**. Whilst the use case for SMR of biomethane is likely to be small, technology also exists for microbes to utilise hydrogen (ideally electrolytically produced using renewables) to combine with the CO2 in biogas to considerably improve the methane content of the biogas and thereby, the AD plant economics. Our paper used the latest knowledge of CO2 biomethanisation and current UK AD infrastructure to estimate the uplift in biomethane production. We concluded that if CO2 biomethanisation was applied in all currently operating UK AD plants, an energy production uplift of 12,954 GWh could be achieved (2020 figures), sufficient to justify the inclusion of CO2 biomethanisation in decarbonisation strategies. Professor Jerry Murphy and colleagues explored this idea further in the 2024 IEA Task 37 brochure on “Circular economy approaches to integration of anaerobic digestion with Power to X technologies”. His YouTube video which also outlines the role of AD within the larger energy system is also useful and our interpretation of that is shown below. AD policy should take into account some of these upcoming technologies or, at the very least, not inadvertently make them impossible to realise.



Under-utilised resources: In order to take advantage of the considerable resource that ca. 90 MT of slurries/manures represents, government needs to ensure the widest possible range of uses for AD and its products. For biogas, this should include electricity and heat production, as well as both off-grid and gas-grid biomethane production and use. A number of factors support a policy which specifically promotes the use of manures and slurries (some already mentioned above and repeated here):

- only **3% of this resource is currently utilised** through AD (in the introduction to the 2011 RASE "A Review of Anaerobic Digestion on UK Farms", Prof Charles Banks of Southampton University estimated this to be a methane potential of around 10 billion kWh of energy per year, an estimated GHG potential of 3 MT CO2 equivalent, a figure which has changed little during the past 13 years
- agriculture has been a **hard-to-decarbonise sector**, responsible for 70% of the UK's nitrous oxide and 50% of its methane emissions, produced form fertilisers and grazing ruminants, respectively - with little change over the past 20 years. The introduction of AD could help reduce these emissions, since the technology essentially captures most of the volatile carbon as methane and carbon dioxide, leaving the more recalcitrant carbon to be returned to soils. In addition to its energy benefits and replacement of fossil fertilisers, AD has other hard-to-monetise agronomic benefits, helping to provide nutrient recycling, killing pathogens and weed seeds, reducing re-grazing time after spreading and the potential associated positive impact on animal health. Whilst many of the methane emissions arise from 'cow belches', there is increasing evidence that the volume of off gases from covered slurry stores is much greater than previously understood, potentially skewing the 'belch/slurry off-gas ratio'.
- Post-Brexit, there is **great uncertainty over farm incomes**, with further worries that cheap imported food grown to lower environmental standards could threaten farm livelihoods. Defra report that in 2019/20 to 2021/22 only the top 50% of farm businesses in England made a clear profit (ave. £79,500) from core agricultural activity alone, with approximately 50% relying on additional income from farm or environmental diversification and direct EU payment subsidies in order to make a profit and the bottom 25% were loss-making, with an average loss from agriculture of £27,800. Diversification provided profit to farms across the board and AD can also be a good diversification option.

- Using such residues through CHP to help **decarbonise farm space heating has a commensurately larger impact**, as many rural properties are off-grid and rely on high carbon (and high price) heating oil. The Climate Change Committee has noted that off-gas homes heated by oil and LPG [are responsible for 8 Mt out of a total of 9 Mt CO2e of direct emissions, with most of these houses located in rural and peri-urban areas]. Additionally, nearly 20% of homes in rural areas are in the lowest F and G energy efficiency bands (compared to just 2.4% in urban areas), so any technology which can utilise local resources to improve this situation has a commensurately greater impact.
- There are good UK examples where on-farm electricity production through AD (and solar) has **encouraged farm electrification**, including the replacement of old diesel pumps or grinders with electric ones, the introduction of electric vehicles such as small loaders, cars and quad bikes and, (in some instances where waste heat could not be used for a given reason), space heating.

Cost-effective and appropriate compliance at small scale: UK AD policy has encouraged increasingly larger sites, so that the income is sufficient to cover the considerable costs of planning, permitting, regulation, operation and compliance. Support for the small farm AD sector should facilitate:

- Access to finance, where farm AD primarily of slurries and manures should be regarded as another piece of farm equipment from a finance point of view
- Regulatory costs and complexity, which makes it harder to install such smaller plants. For example, business rates consistently regard (and charge) AD as 'industrial sites' when at this scale they are not; such perspectives further disadvantage introduction of the technology against the status quo.
- Application of a given activity against the use hierarchies mentioned above. For example, a WRAP project we were involved in planned to utilise local village pub/café food waste which had been macerated and pasteurised in a mobile system (mobile Hub and PoD), then transported 1 mile down the road as a compliant product to supplement the performance and economics of a slurry-only farm digester, particularly useful in summer when the cows were outside grazing. However, the authorities involved considered this to be a farm vehicle movement and preferred to transport the food waste to a site many miles outside the county.

3. In your view, what are the most important barriers to market growth that need to be addressed and why? Please provide supporting evidence.

Lack of support for smaller scale off-grid plants has already been mentioned. Rough calculations indicated that under the Farm and Conservation Grants (1989-95) for pollution control, AD plants were used mainly for house/dairy heating and were typically around 120 m3 in capacity (12 kWe equivalent). Under the FIT, the majority of farm digesters fell into the sub-500 kWe and sub-250 kWe bands. Digester sizes increased further under the RHI, typically in the region of 1-2 MWe equivalent in order to absorb the higher capital cost required for grid injection. The GGSS completely excluded smaller off-grid plants and policy should rectify this. Gas use should be flexible and site-dependent: heating/cooling, electricity, upgraded off-grid to biomethane or grid injected.

Planning, permitting and compliance costs have also been mentioned. Exemptions for these small systems are hugely important, as is permitted development. However, care should be taken if permitting costs are to be introduced or raised, particularly at these small scales where there is generally no large surfeit of income. An example of this could be a covered slurry store where no permitting charges are necessary for such an activity if the gas is vented on an ongoing bases and when the cover is removed for slurry spreading. If, there is a permitting cost should the farm decide to do the more environmentally responsible activity of recovering and utilising the gas in a CHP, a boiler or in an upgrading system, that cost needs to be covered by the income generated through that recovery; additionally, any increase in a permitting cost needs to be covered by a commensurate increase in income or the operation simply is not viable against the less environmentally responsible status quo.

It would also be desirable for small modular systems or slurry covers with gas utilisation to have type recognition within the Environment Agency.

Lack of longer-term vision and policy. Whilst very welcome, the GGSS has been limited in scope. Investor and supplier confidence is increased with certainty around long-term policy and clear roadmaps for the future of the gas grid. Policy must also not have gaps: for example, there were clear deployment drops when the FIT scheme was paused and when the RHI ended and the GGSS began. A small-AD policy could be introduced whilst the GGSS is still in operation, as could a clear policy for those AD assets which would be stranded when their RO/FIT/RHI support comes to an end. In addition to a follow-on from the GGSS, such policies would be welcome.

Propanation for grid injection. Adding fossil fuel to biomethane within the gas grid is a practice peculiar to the UK and is not environmentally responsible; for technical solutions, surely it is possible to look to Europe or elsewhere in order to remove the need for this.

4. Are there any production methods that could have significant potential which are not included in Chapter 1?

No response.

5. Please provide evidence related to the outlined assessment criteria for any of the production technologies listed in Chapter 1 (or for any additional technologies not included).

The industry has discussed the principle of **contracts for difference** for small to medium digesters. Although sharing the same nomenclature, it should not be confused with the CfD which primarily benefits large offshore wind (AD is technically eligible but we are not aware of any systems which are able to use this restrictive scheme).

This type of CfD would have a strike price set by government, rather than a market price. The price could reflect the environmentally desirable outcome (and energetic penalty) of using slurries and manures, as well as other desirable outcomes such as CO2 capture and utilisation (using the hierarchy) to reflect the extra capex/opex for the relevant equipment. There could also be a t**ariff premium** (such as Germany introduced) to reward the inclusion of manures and slurries.

Chapter 2: The role of biomethane in meeting net zero and energy security

6. What are the most important end-uses for biomethane in the transition to net zero by 2050, and what are the implications for the framework? Please provide supporting evidence where possible.

Provision of direct replacement to natural gas and fossil fertiliser and reduction of UK reliance on fossil fuels – this should include off gas grid utilisation as well. The impact of replacing high carbon intensity fossil fuels with low carbon biogas/biomethane in off gas-grid rural areas has been discussed above.

Despatchable power – there have been some excellent examples where DNO's have contacted CHP operators to use stored biogas for short periods of time to support the electricity grid during peak power requirements. With household electrification being the generally agreed way of decarbonising heat for the majority of use cases, a robust electricity system becomes increasingly important. The use of technology to shift load (e.g. Octopus Time of Use tariffs) is important, but judicious use of stored biogas coupled with technology (apps) to help respective grids meet gas and electricity demand should not be overlooked.

Data Gathering and Measurement – whilst the AD industry as individual plants measure the amount of electricity produced, the amount of gas that is grid injected and the amount of gas sent to transport under the RTFO, from a macro view, the data sources are often varied, inconsistent and opaque – for example, DUKES figures for biogas/biomethane have a certain element which is solely in the realm of Ricardo and the NNFCC. Electricity generation at ELEXON level, for example is lumped under 'biomass' and therefore largely overshadowed by Drax. We cannot optimise or sensibly utilise what cannot be properly measured. As a principle, this data should be freely available and transparent in order for both academia and industry to better understand environmental and carbon impacts, energy systems considerations, and future scenario modelling. The author has seen generation data, for example, where load factors are skewed by a few small sites which are permitted for large generation volumes, but have never actually built the generation capacity. Robust feedstock and geographical data would also help with biomass mapping, land use considerations, understanding of nutrient flows (e.g. in NVZ's and areas where P overload is imminent) and might be a way a way for planners to help match biomass arisings with biomass transformation facilities. Such knowledge might, for example, prevent excessive capacity and feedstock competition in some regions and treatment undercapacity in other regions.

Decarbonising HGV's – whilst battery and fuel cell technologies have made impressive leaps forward, the positive environmental impact of immediately introducing low carbon technology such as biomethane is much better than waiting years for 'net zero' technologies to sufficiently develop. Biomethane (bioCNG) can exceed the 20% emissions reduction potential of natural gas over diesel, thereby reducing emissions from a 42-tonne HGV by more than 80%. Many large organisations are increasingly switching to bioCNG to reduce emissions now as part of their carbon reduction strategies. Investor confidence is undermined by a lack of clear messaging and realistic timelines over the introduction of 'zero emission' HGV transport.

7. What might be the impact on the UK biomethane market if the government were to set a form of biomethane volume target? Please provide evidence.

A 'biomethane' target implies gas grid injection and therefore limits the scope. A roadmap with various uses (outlined above), accompanied by robust modelling data (including potential feedstocks and digestate land bank) would be more helpful as part of a larger biomass strategy for the food production and processing sectors.

8. What are the benefits and risks associated with the different approaches (to Time Horizon, Scope and Volume) listed under the production targets section?

No response

9. To what extent will the framework described in Chapter 1 help support an industry that can attract investment and produce enough biomethane to meet the strategic aims in Chapter 2?

The framework described in Chapter 1 is sound and aligns with the strategic aims of Chapter 2, although it should be noted that many of the biomethane (grid) assumptions, as well as the investment language used in the consultation document apply mainly to larger systems and therefore need to be framed differently for small-scale slurry/manure AD.

10. What is the current and potential scale of revenues from the green gas certification market? To what extent can this revenue enable future biomethane deployment, and how could the future framework support this? Please provide evidence to support your response

No response.

Chapter 3: Accelerating growth of the sector

11. What is the current and potential scale of revenues from RTFCs? To what extent can these revenues enable future biomethane deployment, and how could the future framework support this? Please provide evidence to support your response.

As noted previously, we are not aware of any AD plant built solely under RTFCs. For a number of reasons, the scheme has had a great deal of price volatility over the past 5 years, with prices varying from a low of approximately 11.7p/RTFC to more than 30p/RTFC. Such volatility does not facilitate investor confidence to build plants using this scheme alone. The above discussion recognises the importance of biomethane within the HGV transport industry and increasing critical re-fuelling infrastructure has been key in facilitating modest market growth in this sector, as companies seek to reduce their carbon footprint. However, unless there is a minimum 'floor price', potential investors will be unable to make a sound business case in such a relatively small and volatile market and therefore, all other things being equal, the RTFO is likely to remain as an 'add on' to other policies, such as the GGSS where switching claims on a quarterly basis is possible.

12. Please provide any evidence on the current or expected costs (CAPEX and OPEX) and revenues relating to carbon capture on AD plants.

No response.

13. What are the most significant barriers to storing and transporting the CO_2 to sequestration sites? Where possible, please answer with reference for a range of different sizes and types of biomethane plants.

Farms slurry and manure feedstocks are diffuse, low value feedstocks and whilst increasingly cost-effective off-grid biomethane upgrading systems are being built (e.g. Bennamann and Metener), carbon capture it is not likely to be a realistic economic option, particularly in the short term. Where there are farm clusters (e.g. John Baldwin's proposed Chester project or Bennamann's Cornwall project), there may be some scope for a CO2 cluster, but in these small-margin systems, the economics are unlikely to stack up.

More importantly is this question's apparent assumption of 'CO2 sequestration sites' which sound like the landfill equivalent of the waste hierarchy, i.e. the worst use case. As part of a larger decarbonisation picture, the use of biogenic CO2 should be preferentially used in other products: transformed to building materials, platform chemicals or fuels or used directly in refrigeration, as solvents, in greenhouses and so on. Outside of existing biogenic CO2 use within the food industry, there are many use cases better than 'CO2 landfill': Lanzatech's technology of 'CO2 to products' has already been mentioned, and other companies exist in this sphere (e.g. Carbon8).

There is increasing concern that an overt and narrow focus on incentivising permanent carbon storage, i.e. 'landfilling CO2' (such as in seabed injection) removes biogenic carbon from potentially replacing other products produced using fossil fuels, a regrettable unintended consequence of such a focus.

14. What is currently preventing the industry from maximising the revenue from selling CO_2, for example to the food and drinks industries? Do you expect opportunities for revenue from this bio-CO_2 market to change over time? If so, how?

No response

15. How can gate fees play a role in underpinning new biomethane capacity and what barriers must be overcome?

No response

16. Please provide further evidence on the potential costs and revenues for production methods discussed in Chapter 1, where you have this information available.

Small farm AD costs have been notoriously hard to ascertain for a number of reasons: the sector has been almost non-existent in recent years, certainly since the introduction of the RHI and GGSS; technology suppliers typically do not provide costs, as they are commercially sensitive information and the scope of such projects can vary considerably – for example, one farm may have to completely upgrade its slurry handling system and another might have to build a large storage lagoon, so it is very difficult to compare like with like. The approach we took in the IEA Task 37 Report on small farm AD and in this paper was to examine a range of potential income streams (fertiliser offset, energy costs, etc) , financing costs and operating costs, and use these to work backwards to a capital cost. The capital costs were then examined in order to determine whether they were in a realistic range. From a policy perspective, this was a useful exercise in determining what a given level of support might work under various market conditions.

Because of recent UK market conditions for small-scale AD, many UK companies have shut down, diversified or pivoted to building larger plant, though there are relative newcomers to the industry such as Biofactory, WASE and Bennaman. Companies with a European base, such as Bioelectric, have much more activity in Europe where there is stronger support for this sector. EBNet would be happy to facilitate introductions to network members if a better understanding of the European market at this scale could inform the consultation. As a rough summary, several countries offer direct 'green electricity' incentives, mainly for slurry/manure feedstocks in AD plants less than 100 kWe (roughly a 1000-cow equivalent, 1000 m3 digester equivalent) of EURO 0.1625 – EURO 0.3240 per kWh. Some have an added green heat incentive.

17. How could biomethane emissions be reliably differentiated from fossil fuel emissions following the combustion of gas extracted from the gas grid (which is a mix of biomethane and fossil-derived methane)?

This is probably a limitation of our understanding of the ETS, but would it not be better to measure what is going into the grid? Every AD operator who injects biomethane into the grid knows down to the last m3 how much gas they inject, as that is their primary income stream and it is highly regulated. Gas companies know (or should know) their potential system losses. Therefore, it must be easier to measure what is going in (fossil vs biogenic methane) and calculate/estimate the emissions from combustion process (using perhaps average boiler efficiencies), rather than use expensive technologies to try to differentiate a biogenic methane atom from a fossil fuel one. Where gas is removed from the grid for transport fuel, this is also highly regulated and monitored and would therefore have different emissions production, as it is via an internal combustion engine with lower efficiencies than boilers. Other ETS schemes must have similar challenges to address.

18. How could the UK ETS account for biomethane in the gas grid to make biomethane production more financially sustainable?

A robust Life Cycle Analysis is going to be useful to this process. Our co-investigator and EBNet LCA Working Group, Prof Jhuma Sadhukhan is interested in this area and through her industry contacts and work on the 'Artificial Intelligence for Anaerobic Digestion' project (led by Michael Short), is has been putting together some models on AD. We would be happy to facilitate further information exchange to inform the consultation if it helps to inform the consultation.

19. How might UK ETS recognition of biomethane in the gas grid affect UK ETS markets?

No response.

20. Which mechanisms are most likely to ensure UK government meet their strategic aims in Chapter 2, and why?

The **modified Contracts for Difference** approach outlined above could make a significant role to small farm AD, as it is useful to address the issues associated with a small and nascent market, whilst still enabling market-based principles such as prices based on uptake and a gentle downward pressure on costs. As noted already, the current CfD primarily designed for wind, has not been suitable for AD. The **direct support mechanisms** outlined above have historically encouraged AD within the UK and are working successfully in Europe, so shouldn't be completely disregarded.

Loans and grants are certainly welcome at this scale and close liaison with Defra initiatives are to be encouraged, so that, for example, grants for slurry store covers should not exclude beneficial utilisation of off-gases.

An interesting example of funding small-scale slurry AD on dairy farms comes from France. In order to reduce their Scope 3 emissions, a large French dairy processor is offering €50k to farmers who wish to do AD to minimise emissions. The companies who offer this should receive tax breaks on the money they are offering.

21. Which mechanisms are most likely to comply with all the principles listed in Chapter 1, and why?

No response.

22. Which mechanisms are most likely to assist with overcoming the barriers to market growth listed above, and why?

No response

Chapter 4: Sustainability

23. a) What are your views on the criteria set out in Chapter 4 for assessing feedstocks?

The criteria are appropriate for crop/virgin biomass feedstocks and not waste/by-product/co-product feedstocks – as such, they are comprehensive. Any measurement and reporting of the data should be as easy as possible to do and should be made publicly available where possible, with the methodology made clear.

23. b) Are there any additional criteria that we should consider?

As a general rule, any additional reporting criteria should not be so difficult and onerous that excessive extra expense is incurred for compliance, particularly at smaller scales where margins are likely to be small and extra cost harder to absorb.

24. With reference to the feedstock sustainability assessment criteria in Chapter 4 (or any other suggested criteria), please provide any data on AD feedstocks that you think we should consider in future policy.

No response

25. With reference to the feedstock sustainability assessment criteria in Chapter 4 (or any other suggested criteria), please provide any data on feedstocks that are specifically used by non-AD biomethane production methods (outlined in Chapter 1).

No response.

26. What are your views on the approaches set out for prioritising feedstocks? Are there any alternative approaches that we should consider for future policy?

We agree that the waste hierarchy should be applied where possible. Site specific issues should also apply – for example, where there are relatively small amounts of a given by-product or co-product which may not be economic to transport to a place which has a better use case within the hierarchy.

It is interesting that some mid-scheme review replies suggested reliance on limits on overall biomethane greenhouse gas emissions, rather than the '50% of biogas yield' threshold. Although there can be variations in AD plant efficiency, the 50% threshold is robust and relatively easy to measure, particularly when taken as an average over time. The science behind GHG emissions quantification and measurement is more complex and is therefore subject to change over time which might present problems. In theory, however, the GHG measurement aligns more closely with policy aims to reduce GHG emissions, as does the policy to encourage the use of sustainable feedstocks through target setting. This latter option sounds quite complex in policy terms, so the detail of the policy would be very important. It is a laudable aim to allow an AD plant a wide leeway to use waste feedstocks; if this is a policy aim, the regulatory (permitting) side should be commensurately adjusted.

The prescriptive approach is least favourable, due to its potential complexity and restrictive nature. The Covid epidemic highlighted challenges around permitting when sites tried to source alternative feedstocks and this approach would only exacerbate that problem.

27. What is the current and potential scale of digestate revenue? To what extent can this revenue enable future biomethane deployment, and how could the future framework support this? Please provide evidence to support your response.

As noted, digestate revenue tends to be cost-neutral or slightly negative. Even recently when fertiliser prices soared after the invasion of Ukraine, demand for digestate went up considerably, though not many sites benefited materially from a commensurate price rise in digestate.

Any framework should recognise that not all digestates are the same. Nano-plastics could be present in food waste digestate, due to the nature of the feedstock – and better waste segregation practices should be encouraged in order to minimise this. At our small digester site in central London which ran for more than 5 years on local food waste from restaurants and cafes, we had no plastic contamination whatsoever, due in part to the scale, as well as to consumer education.

Digestate derived from the treatment of sewage through AD can contain many things, and scientists are not certain of the eventual fate in the wide variety of treatment systems of the myriad number of personal care products, licit and illicit pharmaceuticals and chemicals outside the relatively small number monitored at wastewater treatment plants. In many European countries, such sludges are incinerated with nutrient recovery for these reasons.

Digestate derived from non-waste digesters does not have to meet any expensive end of waste criteria, and it makes a good product. Sites such as Apsley Farms in Hampshire sell digestate fibre into the consumer market, and it makes a good peat replacement option for household use and in horticulture.

In the late 90's, Heritage Compost carried out extensive peat free growing trials on AD digestate fibre blends from dairy and pig operations and their products won a number of awards. Their composts and those produced by other small farm AD sites were widely sold to local consumers and well-received. However, current legislation would now prevent the sale of such products (and the income diversification), even though they are plastic free, as there is no low-cost, low-risk position for such digestates. It would be good to have one for this scale, as meeting current end of waste criteria is too expensive. The peat free horticulture market might present an interesting opportunity for some use of digestate in horticulture, though nutrient variability has always presented a challenge.

At the very small end of the market (< 20m3 digesters), I have used unpasteurised food waste digestates for growing food for many years, with digesters either strictly vegan or, in the case of personal digesters, not. At this scale, risk is managed in much the same way that liquids from 'compost teas' made from manures, comfrey and other organic additions are managed: with sensible utilisation, keeping the material away from leaves, particularly those that are uncooked. At this scale, liquid digestate is used as an excellent compost accelerator. We have also mixed the fibre with other products such as coir, wool and biochar to make a good peat free growing medium.

EBNet's predecessor, the Anaerobic Digestion Network, funded some successful growing trials on digestate, as well as a trial which successfully used digestate fibre as part of a mushroom compost growing mix for a large business growing mushrooms and vegetables.

On larger sites, we have increasingly seen further digestate treatment technologies introduced, including ultra-filtration, reverse osmosis and recovery of nutrients (e.g. nitrogen). These are options which offer great potential at larger scales but are likely to be too expensive for smaller systems.

28. What are the barriers, if any, preventing UK AD sites and farmers/landowners from implementing additional ammonia abatement methods, such as the ones identified in the 2023 WRAP study for DESNZ?

The barriers primarily fall into the financial and technical realms, particularly at the smaller scales. We are aware of at least one site who trialled a low-cost acidification system, but this was predicated on a supply chain which was very much site specific. The site also experienced a number of technological challenges.

Covered digestate storage is necessary, as are low-emission spreading methods and there should be continued policy focus to promote these relatively straightforward options.

If farmers are being increasingly encouraged and incentivised to cover slurry stores in order to minimise ammonia emissions, beneficial utilisation of off-gases should also be encouraged.

Should further, more complex and expensive ammonia abatement methods be identified (e.g. acidification, stripping/scrubbing), then further support mechanisms, (e.g. grants, tax credits) could be introduced, as well as demonstrators for education, training and knowledge exchange.

29. How do you consider nutrient balancing in relation to your handling and use of digestate? We particularly welcome views from landowners, farmers, and AD operators.

Farmers are encouraged to have a nutrient management plan and the RB209 Guide has been continuously expanded and modified with the latest knowledge and best practice in the application of fertilisers ad organic materials to crops and grassland.

In the past, problems have arisen where developers built digesters without recognition of the land base nutrient requirements or, particularly as the digesters get larger, the transport distances/cost to deploy the material to the increased land base. New systems should certainly ensure that they have sufficient land base to deploy their digestate on.

Again, the mechanisms for digestate deployment may be different for different digesters and policy should recognise this. Food waste plants may have contracts with local landowners and arrangements for digestate storage off-site (and on the farm). Some farm digesters use their own equipment to spread digestate on their own land; others use contractors. At small scales, farmers might try to minimise transport by spreading locally on their own and neighbour's land, particularly if the farmland was widely geographically dispersed.

Farms will often separate the digestate into its fibre and liquid portions in order to use the bulk of the nutrients appropriately, using the liquid containing the bulk of the nitrogen on (say) grassland and the fibre (with recalcitrant carbon and bulk of the P) on arable.

Digestate liquid can also be irrigated onto ground and we are aware of at least one site which utilises irrigated digestate to produce blueberries, a further farm diversification activity.

30. What are the practicalities, costs, and potential environmental impacts associated with transporting digestate to areas with a nutrient-deficit? Please provide evidence to support your response.

In the early 2000's, Holsworthy Biogas plant was established in Devon in order to replicate the Danish model of centralised farm AD, as Holsworthy had a concentration of dairy farms. The site very quickly established that even though the farms were relatively close to each other, the economics of transporting slurry to the digester and digestate from the digester didn't stack up. Since digestate is usually 3%-8% dry matter, it is mostly water, so it cannot be transported long distances. Danish AD sites tend to combine food waste and farm wastes.

We are aware of at least one AD plant in a nutrient dense area who are installing nutrient stripping technologies in order to facilitate transfer over longer distances. This represents an appreciable investment, as well as a technological challenge. The Tully Biogas Plant in Ballymena implemented mono-digestion of chicken litter with nutrient stripping and a detailed case study is shown on the IEA Task 37 website here.

31. Can all AD food waste plant operators accept and process food waste with caddy liners or other food packaging included

Food waste AD facilities that we are aware of do not like compostable caddy liners, as they stretch and foul equipment. Our small food waste digester in London's Kings Cross used paper caddy liners and these worked well with the AD process but are reportedly too expensive to deploy at scale.

32. If liners and food packaging are included, what material types a) are AD plants able to process? b) are preferred? c) are least preferred and why?

No response.

33. If liners and food packaging are included, are they typically: a) not stripped (i.e. left to be treated by the AD process)? b) stripped and sent to a separate composting phase on-site? c) stripped and sent to a separate composting facility (off-site)? d) stripped and sent to incineration? e) stripped and sent to landfill? f) other (please describe)

No response

34. Please provide any evidence you have on the benefits and costs of detecting, monitoring or repairing methane leakage from AD sites.

Prof Penny Atkins and her colleagues at IFEAA are aware of companies who do this.

For many years, the Swedes have had a voluntary system for control of methane emissions and details of that can be found on the IEA Task 37 website here.

It should be noted that slurry and manures produce methane during their natural degradation (the status quo) in any case, so methane slippage on these smaller plants does not have as great an environmental effect as (say) that of a large crop only digester where that crop would not have produced those emissions during its normal life cycle outside of AD. Therefore, costs of monitoring, detection and implementation should bear this in mind and be proportionate in order to encourage best practice.

35. What challenges might the biomethane industry face if future government policy sets a limit on fugitive methane emissions from biomethane production?

No response.

36. What are the key sustainability considerations for any non-AD biomethane production technologies that could be in scope for the future framework? Please specify which technology your answer relates to.

No response.

Chapter 5: Planning and standards

37. Have you experienced or are you aware of any challenges with the planning process for AD plant developments? If yes, please provide details.

Anyone who has worked in this sector for any time will have faced considerable planning challenges which fall under the general headings of lack of consistency in guidelines and criteria; lack of knowledge by planners; and excessive costs and time required for stakeholder engagement, where different stakeholders may even have differing viewpoints.

For smaller onsite plants, working with local authorities can be challenging due to the lack of understanding of the differences between on-site AD located at the source of feedstocks and the larger food waste or crop-based plants, particularly where they need to import feedstocks.

38. What type of AD-specific information would be useful to local planning authorities when reviewing planning applications for AD plant development?

It would be useful to have clear standardised project evaluation guidance from the government to local authorities, as well as specialist support and training. Planning should acknowledge the importance of AD plants in achieving net-zero goals. In the example mentioned previously where an operator wished to add a modular carbon capture and utilisation system to his plant, the planning would take many months and cost a lot of money, thereby discouraging such activities which are patently strongly aligned with net-zero goals.

The planning and regulation should take into account the scale of the AD plant and the relative risk of these smaller plants when compared with normal slurry storage systems, particularly as covered slurry storage is increasingly encouraged.

'Type approval' for regulators would also be useful for planners, especially for smaller modular systems. The approval could include various measures to mitigate risk and inform the planning process and stakeholders.

For these small AD plants treating mainly slurries and manures (including covered stores with gas recovery/utilisation), planners should treat the system as if it were simply an advanced slurry management system. Traffic impact is often challenging, as we have seen planners try to ban planning due to the traffic movement associated with moving chicken manure into a small digester but allow the same movement onto an adjacent field: one is an 'industrial facility traffic movement; and the other a farm transport movement.

When councils develop their own decarbonisation or Net Zero plans, they should also work with their planners to help them recognise the impact of measures to curb farm and other rural emissions on the planning process. There is a need for planning guidance for rural local authorities that reflects the range of AD solutions including smaller scale modular units.

39. What are the benefits and risks that need to be considered in changing the permitting regime to apply the same regulatory standards to AD sites processing waste and non-waste?

It is a strange regulatory loophole that a small slurry AD plant is subject to a large swathe of regulation that is not applicable to large crop-based plants. Going forward, the same standards should apply. Retrospective permitting might very well be more problematic and require its own consultation in order to ascertain costs and other compliance implications. However, EA resource implications need to be considered, as there are real concerns on the time required for processing permits and permit variations.

40. What are your views on the feasibility and usefulness of developing industry-wide guidance on design, maintenance and operation standards for AD plants?

About 15 years ago, we had discussions on Best Available Techniques and there were fears that this would stifle innovation. Whilst standards are laudable and necessary, not every plant can afford the costs associated with implementing these for each site, so lower cost mechanisms such as 'type approval' should be sought. Cost effective operator training/testing and certification could also be possible, as even the home micro-systems do inexpensive online training.

The guidance would have to be very general. For example, one UK AD supplier has an automated de-gritting system built into the digester, so mandating digester closure, grit emptying and digester re-filling as a maintenance practice for such systems is an unnecessary and rather pointless expense.

41. What is the impact of grid capacity, now and in the future, on the development, operation and output of biomethane plants? Please outline where this differs between distribution and transmission level and between production technologies.

No response.

42. Are there any steps the government and the industry could take so that biomethane producers could more easily access reliable grid injection capacity?

No response

43. Which technologies, including reverse-compression, could increase grid capacity access for biomethane plants and what are the associated costs and barriers? Please provide evidence for your suggestion, including details on costs where possible.

No response

44. What steps need to be taken by the biomethane industry, gas networks or the government to reduce or remove the need for propane in preparing biomethane for injection to the gas grid while maintaining fair billing for gas customers?

As mentioned previously, the requirement for propanation (particularly for the relatively small amounts of biomethane injected) is it also imposes unnecessary costs for construction and operation of AD sites, as well as being environmentally irresponsible. Removal of this extra cost would surely not adversely affect gas customer billing: nowhere else in the world are customers adversely affected. Gas companies do claim that they cannot deal with variable CV's, but they do small changes to CV's on their billing in any case.

45. What are your views on the best approach to enable optimal plant locations in the future framework? How might this differ across different production technologies?

Whilst a better understanding of infrastructure locations, biomass arisings and land bank nutrient levels would be useful to the sector and inform policy, top down, government-led approaches have historically not had good track records.