CAG CONSULTANTS

Evaluation of the reformed Renewable Heat Incentive

ANNEX A1 - BIOMETHANE APPLICANT FIELDWORK WORKING PAPER

INFORMING POSITIVE CHANGE

Department for Business, Energy & Industrial Strategy (BEIS)

Department for Business, Energy & Industrial Strategy

This paper was produced for the Department for Business, Energy and Industrial Strategy as part of the evaluation of the reformed Renewable Heat Incentive.

FOR DIRECT ENQUIRIES ABOUT THIS REPORT:
Tim Maiden
Partner
CAG CONSULTANTS

Mob: 07961 541281
Email: tm@cagconsult.co.uk

TO CONTACT CAG CONSULTANTS:
CAG CONSULTANTS
150 Minories
London EC3N 1LS

Tel: 020 8555 6126
Fax: 020 7900 1868

hq@cagconsult.co.uk
www.cagconsultants.co.uk

Executive Summary

Context

A package of reforms to the non-domestic Renewable Heat Incentive (RHI) scheme were announced on 15 December 2016. The reforms aimed to 'vastly improve the carbon cost-effectiveness of further support'[1]. This included a small uplift to tariffs for biomethane injection, which were only accessible to new plant which met the requirements of a further reform - that all new plant should produce at least half their biomethane from waste-based feedstocks in order to receive support for all their production. New plant not meeting the later requirement was still able to access the old tariffs until the reform regulations came into force on 22 May 2018. From that date onwards, the increased tariff and feedstock requirements applied to all new participants.

The reforms also included the introduction of tariff guarantees, which aimed to provide investors with greater certainty regarding their tariffs earlier in the project cycle. These were available to all biomethane applications from 22 May 2018 onwards.

Prior to the tariff guarantees being introduced, biomethane installations were able to secure a tariff rate prior to completion of the biomethane installation. This could be achieved by injecting some biomethane (potentially from another source) to the grid at the planned entry point. The potential to pursue this 'two-stage commissioning' process was removed under reforms which were announced on 29 May 2018 and came into effect on 20 June 2018.

A further reform introduced as part of the December 2016 package of reforms was the removal of digestate drying as an eligible heat use under the RHI. This reform became effective on 22 May 2018.

Research was needed in order to gain a deeper understanding of the role that the RHI plays in the decision-making around the pursuit of biomethane installations and to explore the influence of the different elements of the reforms.

Approach & methodology

The evaluation of the reformed RHI is structured around theory-based evaluation methods. This working paper presents, tests and refines the theoretical framework for the evaluation, which is framed in realist terms. The theoretical framework hypothesises combinations of 'contexts', 'mechanisms' and 'outcomes' (CMOs) through which the RHI is expected to contribute to its objectives. Candidate theory was developed for biomethane. This included a series of CMOs focused on the role of the reformed RHI on the business case for biomethane installations, which were then tested and refined in the course of the research.

Qualitative research, in the form of in-depth semi-structured telephone interviews, was undertaken with 18 RHI applicants and nine wider stakeholders involved in the supply chain for biomethane. Purposive sampling was utilised to ensure that the 18 applications reflected the diversity of biomethane applications which were submitted after the reform announcements in December 2016, including those submitted before and after the principal reforms came into effect in May 2018.

[1] BEIS (2016) *The Renewable Heat Incentive: A Reformed Scheme. Government Response to Consultation*.

Findings

The key findings below are structured around the three questions set for the research.

What role did the RHI play in the business case for biomethane installations which were the subject of RHI applications, and how did this interact with the other factors in the marketplace?

In our research we tested a scenario in which the RHI was simply a windfall, i.e. irrespective of the RHI, there was a viable business case for investment in a biomethane installation. Such cases were not observed in our research, although some stakeholders did see a prospect for some future biomethane development in the absence of the RHI, as discussed further below. In all cases in our research, the RHI was critical to the business case for the development.

Revenue streams from other sources were insufficient to make schemes viable. RHI was the most significant income stream in all of the business cases we observed, typically comprising 70-80% of the income or expected income for an installation. Gas sales were the next most significant, comprising most of the remaining income, but unlike the RHI the income from gas sales fluctuates. This further enhanced the importance of the secure and steady income from RHI in underpinning business cases for biomethane investment.

Although the RHI has underpinned a significant growth in biomethane, a range of other factors have counter-acted this incentive. The research confirmed that a relatively complex set of general contexts (or requirements) would normally need to be in place for any biomethane plans to proceed to the point of considering an RHI application. These general contexts included cost-effective access to feedstocks which met the feedstock rules, land, planning permission and grid entry. Some of these general contexts were challenging and together comprised a significant barrier to biomethane investment.

What role did the different elements of the RHI and scheme reforms (in particular the feedstock rule, tariff uplift, tariff guarantees and removal of two-stage commissioning) play in the business case for biomethane plants?

In most of the cases observed in our research, not only was the RHI per se critical, the reforms to the RHI were also critical to the business case for the development. The uplifted tariff enabled the necessary return on investment in all cases. To illustrate this, degression in the RHI tariff in January 2019 was seen by most respondents to have removed the prospect of any significant further investment in biomethane at the present time. The de-risking of investment provided by tariff guarantees was also important in some cases but other cases proceeded either:

- with similar de-risking achieved through the two-stage commissioning, which required a higher level of early investment than tariff guarantees but which could be pursued in advance of tariff guarantees becoming available; or
- without any such de-risking of the investment, i.e. applying to the RHI once the construction of the plant was complete.

A further reform introduced in December 2016 was that in order to access the uplifted tariffs, all new plant should produce at least half their biomethane from waste-based feedstocks in order to receive support for all their production. Although not observed directly in our sample of applications, stakeholders indicated the presence of cases in which the reforms to feedstock rules negatively

impacted on schemes reliant on crop feedstocks which were being planned at the time of the reform announcements and which could not be adapted to meet the new feedstock restrictions. However, it was also suggested that tariff degressions had led developers away from crop-based schemes and towards cheaper waste-based feedstocks anyway.

The influence of the RHI and scheme reforms varied significantly across the different contexts explored in the research. A number of key contexts/factors appear to have played a causal role in determining the nature and extent of this influence, including the cost and source of development finance, the cost and source of feedstocks and the extent to which biomethane investment aligned with the wider business imperatives of the developer.

These factors are illustrated in relation to the need for the uplifted tariffs in Figure 1 below. The size of the bubbles provides a rough indication of the relative significance of each of the factors in reducing the need for the uplifted tariffs. Where one or more of these factors were present, the applicant may have been able to proceed with a lower tariff.

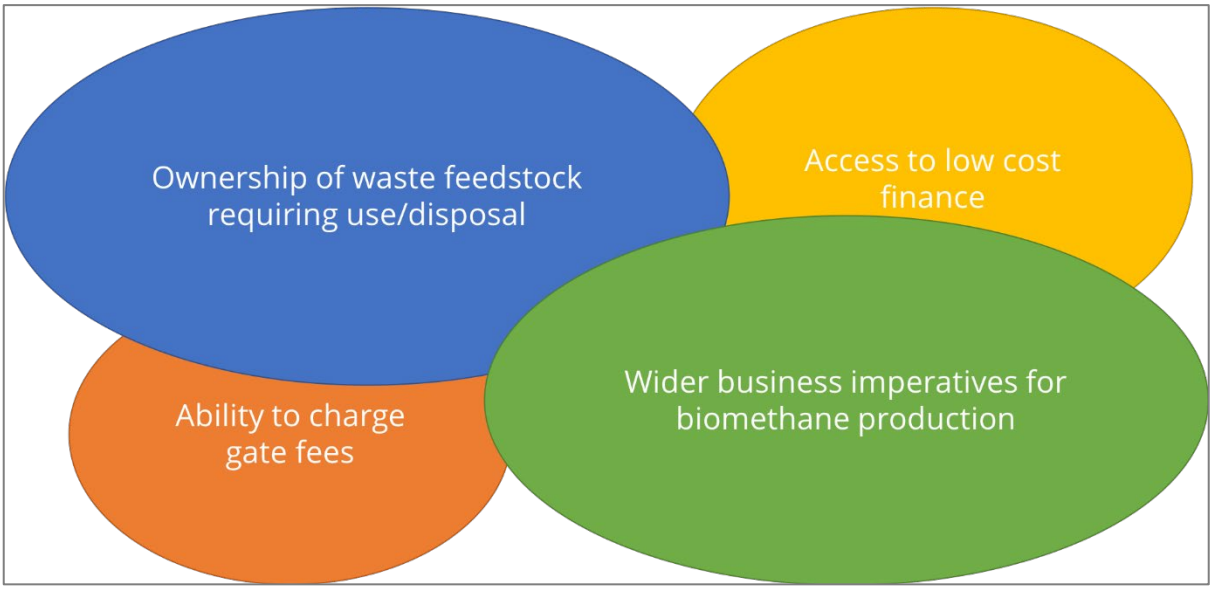


Figure 1: Key factors which reduced the need for the uplifted RHI tariffs

The key factors which reduced the need for an early certainty of the RHI tariffs are illustrated in Figure 2. Where one or more of these factors were present, the applicant may have been able to proceed without a tariff guarantee and instead either: with the more expensive and risky option of two-stage commissioning; or without any early confirmation of the tariffs at all. Again, the size of the bubbles provides a rough indication of the relative significance of each of the factors in reducing the need for an early certainty of the tariffs.

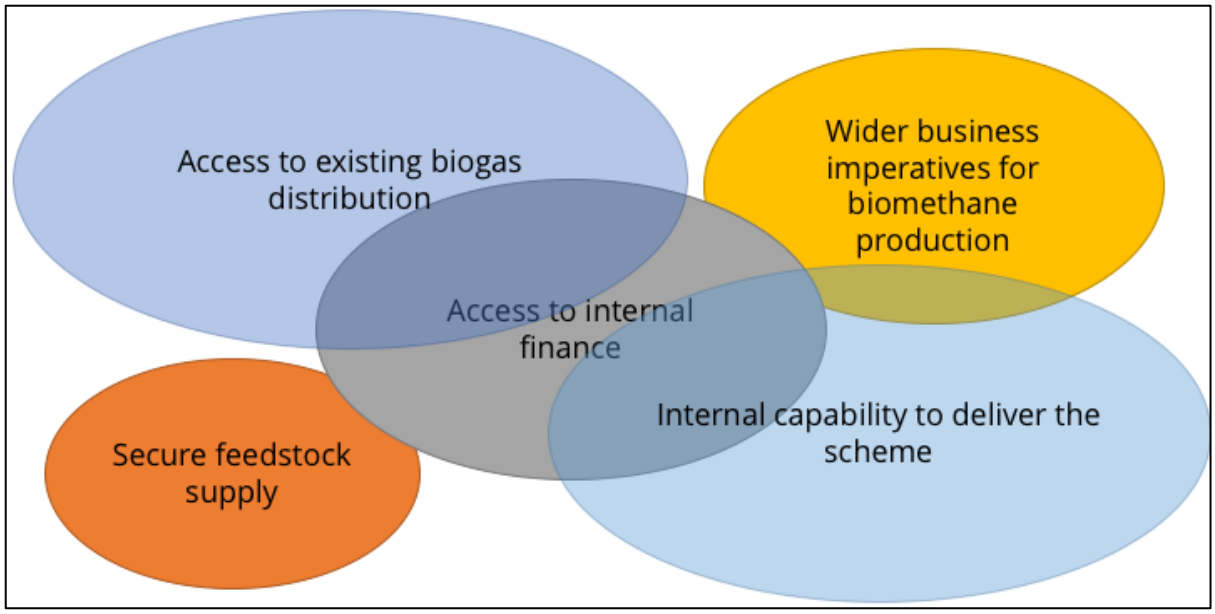


Figure 2: Key factors which reduced the need for an early certainty of the RHI tariff

The way in which these different factors combined in the cases encountered in our sample is illustrated in Table 1 below. Table 1 illustrates the prevailing trend for each group; however, given the complex setup of each biomethane plant, the real-world situation is not as black and white. Each applicant reported needing the uplifted tariffs or tariff guarantees to differing levels depending on their context.

Table 1: Overview of cases observed

Observed cases	Needed uplifted tariffs	Needed tariff guarantee
Developers seeking short-term profit from investment in biomethane, who had a relatively insecure and costly feedstock supply (fully or partly food waste) and external equity-based or high-cost debt finance. They were therefore reliant on the uplifted tariffs, and the reduced investment risk offered by tariff guarantees, to achieve a fundable business case.	✓	✓
Developers with a secure feedstock supply, who were reliant on the uplifted tariffs to achieve a viable business case and using tariff guarantees to facilitate access to external finance. Some such plants, however, may have been able to proceed without these guarantees.	✓	?
Developers with access to a secure feedstock supply, who were reliant on the uplifted tariffs to achieve a viable business case. They did need to de-risk their investment through securing their tariff as early as possible, but their funding arrangements meant they were able to do so using two-stage commissioning rather than tariff guarantees.	✓	✗

Water companies with a secure feedstock supply and existing biogas generation, who were relying on the uplifted tariffs and utilising either tariff guarantees or two-stage commissioning to reduce investment risk and achieve a fundable business case with internal finance.	✓	✗
Developers linked to, or part of, companies with wider long-term business drivers for biomethane development, who were utilising either the proven biogas supply from existing AD plants or access to a secure local feedstock supply to achieve a viable business case with the uplifted tariffs. Access to internal finance and the wider business imperatives, however, meant these developers had no need for the de-risking provided by two-stage commissioning or tariff guarantees.	✓	✗
Farmer applicants with a relatively secure feedstock supply, access to low-cost debt finance, and wider environmental and business drivers for biomethane/AD, utilising the uplifted tariffs and reduced investment risk offered by tariff guarantee.	?	?
Manufacturing companies with a secure feedstock supply, which were reliant on RHI and benefited from the reforms but had a viable business case, irrespective of the reforms, due to wider business imperatives and access to internal finance.	✗	✗

The way in which the reforms were implemented may have undermined growth in the level of deployment. A particular issue identified by applicants and wider stakeholders was the January 2020 deadline for commissioning schemes with a tariff guarantee. The delay in tariff guarantees becoming available, coupled with reported delays in the tariff guarantee approval process and subsequent concerns about potential supply chain bottlenecks, meant that a significant number (c.50%, according to some stakeholders) of tariff guarantee schemes were considered to be unlikely to proceed at the time of the research.

What would have happened without the RHI and without the reforms to the RHI? How would this have altered the business case for biomethane plants?

Given the pivotal role of the RHI which we observed in underpinning investment in biomethane, it is unlikely that any biomethane investment would have taken place in the absence of the RHI. We do not have comprehensive data on what would have happened in the absence of the RHI biomethane tariff, other than that none of the schemes in our sample would have taken place. Some applicants with a secure feedstock supply said they would have pursued biogas combined heat and power (CHP) but others said they would have done nothing apart from monitoring opportunities to develop biomethane schemes underpinned by other subsidies (such as Renewable Transport Fuel Certificates) in the longer term.

It is likely that there would have been a significantly lower level of investment had the reforms not been implemented. Most of the cases in our research were reliant on the uplifted tariffs to achieve the necessary returns on investment and many also required the de-risking of that investment which was provided by tariff guarantees. We found only one set of contexts in which the business case was not reliant on one or more of the reforms – manufacturing companies with a secure feedstock supply,

which were reliant on RHI and benefited from the reforms but had a viable business case, irrespective of the reforms, due to wider business imperatives and access to internal finance.

Unsurprisingly therefore, ongoing financial support for biomethane was considered necessary, as were mechanisms, like tariff guarantees, to manage the uncertainty associated with tariff degressions. As already noted, degression in the RHI tariff in January 2019 was seen by most respondents to have removed the prospect of any significant further investment in biomethane at the present time. This is consistent with the observation that there have been only two active biomethane applications since the tariff degressed by 15% in January. It is not yet known whether many new plants will come forward at the lower tariff rate now that the tariff guarantee completion deadline has been extended to January 2021, as announced in May 2019.

However, we did observe cases in which developers had a business imperative to make sustainable use of their own waste stream and were therefore less reliant on the uplifted tariffs and tariff guarantees. It was suggested that such contexts may provide some opportunities for biomethane investment at current RHI tariffs and even in a post-RHI context, particularly if the incentives for electricity production remain low.

Some respondents envisaged market prospects for biomethane being enhanced by changes in waste collection regimes, particularly increases in food waste collection by local authorities, which could lead to increased gate fees for such waste. The market may be further aided by initiatives by the gas network operators to facilitate grid injection.

The prospects for biomethane will not simply be dependent on the RHI and any successor scheme, however, but also on wider Government policies such as:

- the support for electricity generation (Feed-in Tariffs (FiTs) and Renewable Obligation Certificates (ROCs)) –the level and availability of these mechanisms are closely tied to decision-making relating to biomethane;
- transport policy and the Renewable Transport Fuel Obligation (RTFO) in particular, operated by the Department for Transport, which currently plays a minor role in decision-making relating to biomethane but was seen to have significant future potential to support biomethane investment;
- EU, the Department for Environment, Food & Rural Affairs (Defra) and Local Authority policy on waste – increases in food waste collection were seen to have important consequences for the future viability of biomethane investment;
- regulatory drivers for the Gas Network Operators – some of these operators were seeking to facilitate injection to their networks; and
- regulatory drivers for waste producers such as water companies, which could influence waste uses and disposal and there availability as feedstock for biomethane production.

CONTENTS

1 Introduction

1.1 This draft working paper presents findings from qualitative research undertaken for the evaluation of the reformed Renewable Heat Incentive (RHI). It has been prepared by CAG Consultants on behalf of the Department for Business, Energy and Industrial Strategy (BEIS). It is part of a suite of working papers presenting findings from research conducted in 2018/19. These working papers will inform the content of a report synthesising key evaluation findings to date.

1.2 This is a working paper, for internal purposes only, and not intended for publication.

Context

About the evaluation

1.3 CAG Consultants, working with Winning Moves, Hatch Regeneris, EREDA and UCL, have been commissioned to undertake an evaluation of the reformed RHI on behalf of BEIS. The evaluation will provide a) an assessment of the impact of the scheme, and b) strategic learning to inform heat policy development. The evaluation is structured around theory-based evaluation methods which will develop, test and refine realist theories about the reformed RHI as the scheme proceeds.

About biomethane

1.4 This study focused on applications to the RHI for production of biomethane for injection into the gas grid. The basic components of these installations are:

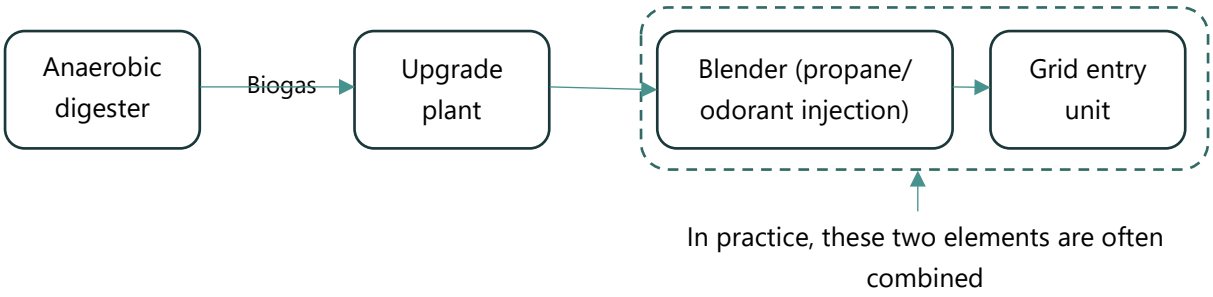


Figure 1.1: Basic components of a biomethane plant

1.5 The upgrade plant removes carbon dioxide from the biogas and this gas can be captured and stored through a liquefaction plant. Where the feedstock is 100% energy crops, this carbon dioxide has a market value as an input to food production and there are a number of companies with a supply chain in place to buy and sell the carbon dioxide. Where the feedstock is not 100% energy crops, the market value of the carbon dioxide is less clear.

1.6 There are four types of biogas upgrade plants currently installed in the UK in biomethane-to-grid plants:

- water scrubbing systems;
- membrane systems;
- chemical absorption systems; and
- pressure swing adsorption (PSA) systems.

1.7 Capital costs of membrane and PSA systems tend to be lower but the operational costs of these systems tend to be higher, particularly because of the electricity costs for compression and the need to replace membranes (in the case of membrane systems) or the adsorbent material (in the case of PSA systems).

1.8 Feedstocks for the anaerobic digester can include:

- farm waste;
- energy crops;
- sewage waste;
- manufacturing/industrial waste – usually food/drink production processes; and
- municipal food waste

1.9 The anaerobic digestion process results in a digestate, made up of solid and liquid components. The solid component can be used as a fertiliser so installations may also incorporate plant for removing the liquid component. Some installations may have plant for drying the digestate using heat generated from a biogas-powered CHP unit or the processing of digestate may occur off-site by a third party. It is understood that the liquid component of the digestate has limited market value but that, depending on the processes used, it may be re-used in the digestate process or to pasteurise food waste plant input.

1.10 Even where there is no CHP for digestate drying, most biomethane installations will incorporate biogas/CHP since the AD process itself has a significant heat demand and the upgrade plant may also have a significant heat (in the case of biogas upgrade via chemical absorption) and/or electricity demand (in the case of waterwash, membrane and PSA systems). This means that most sites, in addition to receiving RHI for the biomethane, also receive:

- separate RHI payments for biogas, paid for eligible heat output – this is treated as a separate installation for the purposes of RHI; and
- Feed-in-Tariffs (FiTs) and/or Renewable Obligations Certificates (ROCs) (but not the ROC uplift) for electricity generated by the CHP.

1.11 The calculation of RHI payments for the biomethane tariff takes account of fossil fuel use in the production process, including the propane and any fossil fuels used for heat generation, e.g. gas boilers. These various principal inputs and outputs are summarised in Figure 1.2.

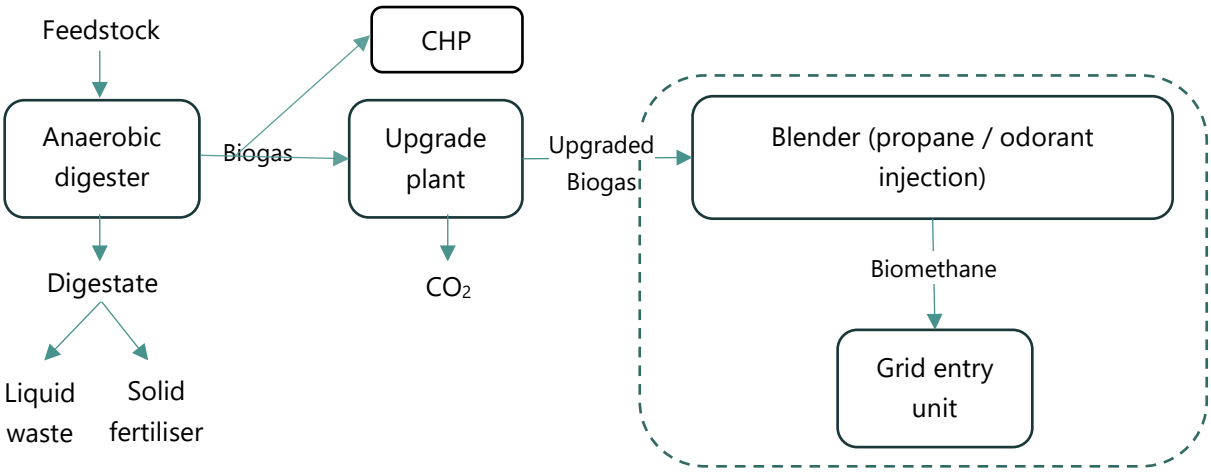


Figure 1.2: Principal inputs and outputs in a biomethane installation

1.12 Key actors involved in biomethane installations vary in each case but can include:

- Landowners, who may or may not own the installation or parts of it
- Feedstock providers, who also may or may not own the installation or parts of it
- Plant owners/operators, e.g. operators of the blender/grid entry plant
- Developers, who may own installations in conjunction with others, including landowners, feedstock suppliers or plant owners/operators
- Financiers
- Digestate processors, users and the associated supply chain
- CO_2 processors, users and the associated supply chain
- Gas network operators who receive the biomethane into their networks and may adopt the parts of the grid entry unit, e.g. so that they can some control over the flow of gas into the network
- Intermediary companies, typically referred to as 'gas shippers', who purchase gas from the installations
- Consultants, engineers and contractors
- Component suppliers, e.g. upgrade units and grid entry units. These might be manufacturers of the equipment or consultants who utilise equipment manufactured by others. In some installations, the biomethane plant equipment may be supplied by one company, e.g. the supplier of the upgrade plant may also be contracted to provide the blender and grid entry unit even though the latter may be sourced from another manufacturer. In an interview with an upgrade plant manufacturer it was suggested that this can help to ensure effective operation of the whole system and reduce uncertainties relating to liabilities for any faults in the system. Suppliers would typically have service agreements with their plant operators, covering maintenance and repairs

1.13 As is clear from the above list, ownership of biomethane installations can often be complex, with different organisations owning different aspects of the installation, and they may involve quite separate entities. For example, RHI applications may have been submitted for developments adjacent to existing AD plants, with the applicant being a separate entity from the AD plant operator but with a contract in place to purchase biogas from the plant and upgrade it to biomethane.

Policy context

1.14 The non-domestic RHI scheme was launched in 2011 and the domestic RHI scheme in 2014. The schemes are intended to support the transition to low-carbon heating in the UK by providing financial incentives to install low carbon heat technologies. The schemes are open to commercial, industrial, public sector, not for profit and community generators of renewable heat as well as homeowners and private and social landlords.

1.15 A package of reforms to the non-domestic scheme were announced on 15 December 2016. These were the latest in a series of reforms for biomethane. Previous reforms included:

- The introduction of a three-tiered tariff for biomethane producers in February 2015, meaning the highest tariff rate was only paid on the first 40,000 MWh of eligible biomethane; and
- The introduction of sustainability requirements for feedstocks in October 2015.

1.16 In addition, as with all RHI tariffs, the biomethane tariffs were subject to degressions on (up to) a quarterly basis. The tariff changes are shown in Figure 1.3.

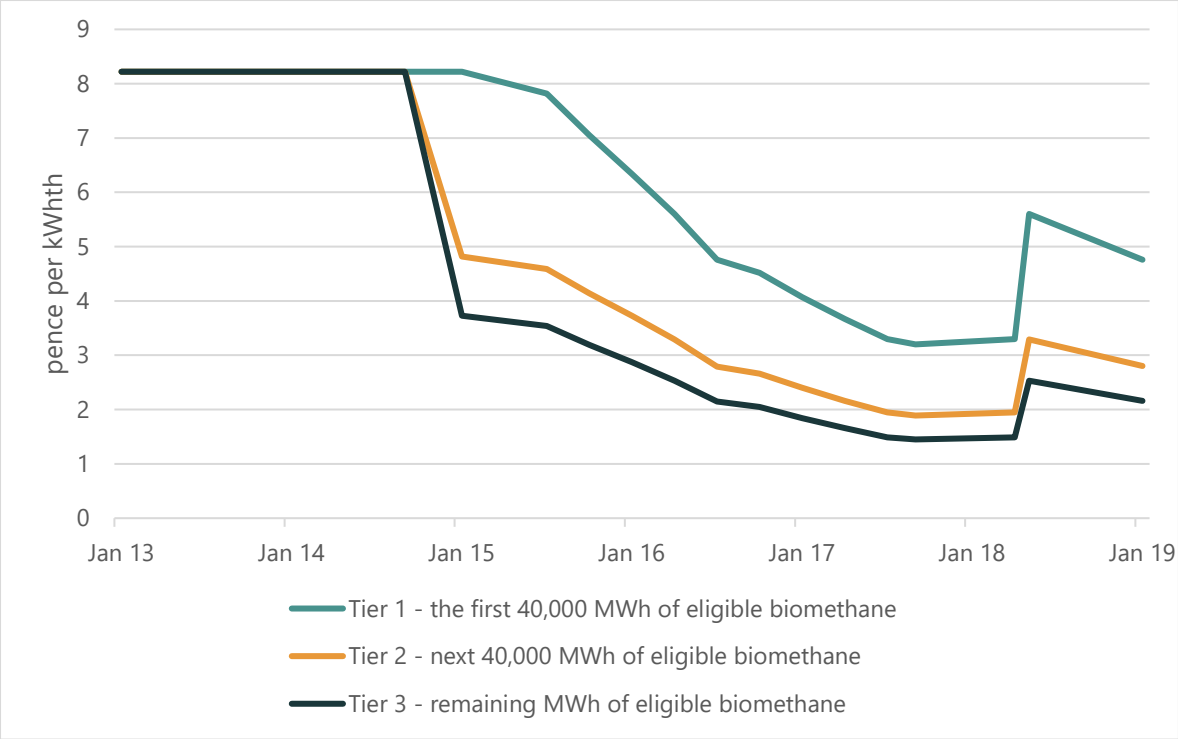


Figure 1.3: Biomethane tariffs

1.17 The reforms announced in December 2016 aimed to 'vastly improve the carbon cost-effectiveness of further support'[2]. This included an uplift to tariffs for biomethane injection (the tariff levels were reset to those available between April and June 2016, i.e. they were increased from 4.52 to 5.6p per kWhth in tier 1), but these were only accessible to new plant which met the requirements of a further reform - that all new plant should produce at least half their biomethane from waste-based feedstocks in order to receive support for all their production.

[2] BEIS (2016) *The Renewable Heat Incentive: A Reformed Scheme. Government Response to Consultation*.

New plant not meeting the later requirement werestill able to access the old tariffs until the reform regulations came into force on 22 May 2018. However, those tariffs continued to degress, to 4.07p in January 2017 and with further degressions until 22 May 2018. From that date onwards, the increased tariff and feedstock requirements applied to all new participants.

1.18 The reforms announced in December 2016 also included the introduction of tariff guarantees, which aimed to provide investors with greater certainty regarding their tariffs earlier in the project cycle. These were available to all biomethane applications from 22 May 2018 onwards. The tariff guarantee process is summarised in Figure 1.4 below.

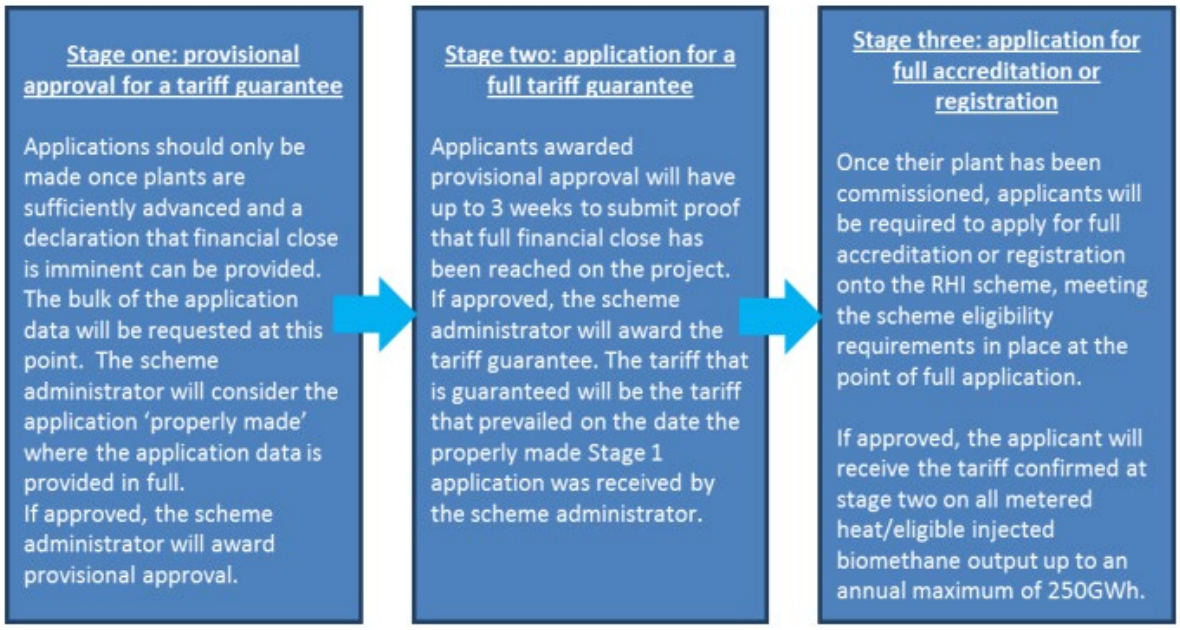


Figure 1.4: The tariff guarantee process (Source: BEIS)[3]

1.19 Even prior to the tariff guarantees being introduced, biomethane installations were able to secure a tariff rate prior to completion of the biomethane installation. This could be achieved by injecting biomethane, potentially from another source, to the grid at the planned entry point. The potential to pursue this 'two-stage commissioning' process was removed under reforms which were announced on 29 May 2018 and came into effect on 20 June 2018.

1.20 A further reform introduced as part of the December 2016 package of reforms was the removal of digestate drying as an eligible heat use under the RHI. This reform became effective on 22 May 2018.

Research rationale and questions

1.21 The research rationale and questions were defined during a workshop with BEIS policy staff in September 2018.

[3] Further detail is available at https://www.ofgem.gov.uk/system/files/docs/2018/05/guide_to_tariff_guarantees_16_may.pdf

Research rationale

1) Future policy development requires a deeper understanding of the role that the RHI (and other influences) plays in the decision-making around the pursuit of biomethane installations.
2) There was a hiatus in biomethane applications pre the 2016 reforms coming into force. High post-reform uptake, under Tariff Guarantees (TGs), appears to indicate that RHI (and its reforms) played a significant role in decision-making. Research is needed to explore the influence of different elements of the reforms, including the introduction of TGs, the removal of 'two-stage commissioning', the requirement[4] that 50% of gas from new plants should come from waste feedstocks and the increased tariffs for new plants that comply with this waste requirement.
3) Following the spike in applications when TGs were introduced, BEIS believe it is unlikely that there will be many further biomethane applications (due to the length of commissioning required), which means that we have a near-complete population from which to draw our research sample.

Research questions

1) What role did the RHI play in the business case for biomethane installations which were the subject of RHI applications, and how did this interact with the other factors in the marketplace?
2) What role did the different elements of the RHI and scheme reforms (in particular the feedstock rule, tariff uplift, tariff guarantees and removal of two-stage commissioning) play in the business case for biomethane plants?
3) What would have happened without the RHI and without the reforms to the RHI? How would this have altered the business case for biomethane plants?

The theoretical framework

1.22 This working paper presents, tests and refines the theoretical framework for the evaluation, which is framed in realist terms[5]. The theoretical framework hypothesises combinations of 'contexts', 'mechanisms' and 'outcomes' (CMOs) through which the RHI is expected to contribute to its objectives. While the theoretical framework is summarised in this paper, full details can be found in the Evaluation Plan for this evaluation.

1.23 The candidate theory relating to biomethane installations is formed of two parts:

1) Biomethane installations: general contexts – these are contexts that would normally need to be in place for biomethane investment by different types of investors using different types of feedstocks, relating to the main different biomethane applicant types. These contexts have been defined on the basis of information from a workshop with BEIS policy

[4] During the interim period, new plants had the option of meeting the 50% waste rule and obtaining the higher tariffs, or not meeting the rule and obtaining tariffs at the pre-reform level.

[5] Realist evaluation is a type of theory-based evaluation. At the heart of realist evaluation is the question: "What works, for whom, in what respects, to what extent, in what contexts, and how?". As such, realist approaches seek to identify the underlying generative mechanisms that explain 'how' the outcomes were caused and the influence of context. See http://betterevaluation.org/approach/realist_evaluation for more.

staff and from scoping interviews with industry stakeholders. These general contexts are shown in Appendix A.

2) Biomethane installations: RHI-specific CMOs - candidate CMOs relating to the influence of the RHI on biomethane investments. These build on the demand theory set out in the overall theoretical framework for the reformed RHI evaluation. We have adapted the CMOs to fit biomethane projects, as opposed to renewable heat projects generally. We have also expanded the set of CMOs to distinguish between different additionality outcomes under the pre- and post- reform RHI. These CMOs are shown in Appendix B.

1.24 The general contexts and candidate CMOs draw on insights from the draft RHI systems map prepared by CECAN (see Appendix C).

About this report

1.25 Chapter two summarises the methodological approach for this research.

1.26 Chapter three sets out the candidate theory for the influence of the RHI on biomethane investments (i.e. our demand theory) and explains how this theory has been adapted in the light of the research. Chapter four then goes on to explore each of the observed CMOs in detail.

1.27 Chapter five provides a summary of other findings from the research, including those relating to the supply theory and wider insights gained regarding the biomethane market.

1.28 Finally, chapter six presents findings from the research regarding the future for the biomethane (and related biogas) market.

About qualitative research findings

Note that this is a qualitative research report and therefore is a presentation of the different views and experiences of those interviewed. It does not aim to quantify the number of participants who held particular views or had particular experiences. This is because "the purpose of qualitative research is not to measure prevalence, but to map range and diversity, and to explore and explain the links between different phenomena."[6]

Other data on biomethane has been gathered in other evaluation workstreams. This data will be synthesised with the qualitative data presented in this report and reported separately.

[6] Ritchie, J., Lewis, J., McNaughton Nicholls, C. and Ormstom, R., (2014), Qualitative Research Practice (2nd edition.). London: SAGE.

2 Methodology

Scope

2.1 The evaluation plan sets out key policy questions relating to the expected reforms and how they are intended and expected to work. These have been defined in conjunction with BEIS. For each policy question, we have identified 'clusters' of contexts that would enable testing of that policy question. Defining these clusters formed part of the initial scoping work, taking account of the findings of previous RHI evaluations, the objectives of the reformed scheme and current policy issues. The cluster which is the subject of this study is biomethane applicants.

2.2 A workshop was held with BEIS staff in September 2018 to further clarify the rationale and research questions for this element of the evaluation. This confirmed BEIS's primary interest in: (a) the role of the RHI in the decision-making around the pursuit of biomethane installations, including consideration of the additionality of the RHI, tariff levels, influences on plant type and size, RHI value for money and the role of other revenue streams; and (b) the impact of RHI reforms on decision-making. These interests are reflected in the high-level research questions listed in paragraph 1.22.

2.3 Other questions relating to future policy development were also highlighted. Although it was recognised that the evaluation may not be able to address them directly, it was hoped that it may generate some useful insights. These questions included:

- Was the RHI the most appropriate way to support the industry? What are the alternatives?
- What is the right size of plant? Smaller numbers of large plants or larger numbers of small plants?
- How will the market respond to other potential policy changes, e.g. could operators react to tightening GHG emissions limits?

2.4 To further enhance our understanding of the dynamics of the biomethane market, which could then inform our approach to research design, it was agreed at that workshop that a small number of scoping interviews would be conducted with key stakeholders. In November 2018 three telephone interviews were subsequently conducted with, a technology manufacturer, a financier and a sector representative.

2.5 The scoping interviews explored:

- the types of biomethane applicants to the RHI, and how they are best categorised;
- the extent of two-stage commissioning by RHI applicants;
- the key factors determining applicants' progress with construction and commissioning;
- the key factors determining the timing of applications vis-à-vis the RHI reforms;
- how to identify the principal decision-maker within applicant organisations; and
- other key stakeholders in biomethane installations, to inform the selection of case study interviewees.

2.6 The findings from the scoping interviews informed the approach to sampling and the design of the research instruments, described below. They also generated some useful data relating to the research questions, so the findings have been included in our analysis and incorporated in

this report. To support this process the interviews were transcribed an analysed in the same way as the applicant interviews (see below).

Sampling

2.7 The findings from the scoping calls, discussions with BEIS policy staff and an initial review of the applicant database suggested that the factors shown in Table 2.1 would be important considerations for sampling.

Table 2.1: Sampling considerations for research with biomethane applicants

Factor	Reason	Potential data source
Date of application	Analysis of the application database and the scoping calls confirmed that the reforms were significant in the decision-making regarding the decision to proceed with a biomethane application. It was suggested in the scoping calls that some applicants were keen to apply prior to the reforms being implemented because, for example, they wanted to avoid the feedstock restrictions, they had other concerns about the post-reform market or they wanted to submit 'speculative' applications with the aim of securing investment later on. The scoping calls indicated that waiting for the reforms was considered to be a potential risk because of the short window between TG approvals and the required commissioning date (exacerbated by delays in the TG approvals processes), a concern about the tariff guarantee leading to the available funding being used up rapidly and a more general perceived risk that the reforms may not be implemented in the way that had been announced, i.e. more certainty could be gained from proceeding in the pre-reform context. Other applicants clearly waited until the reforms became effective because of the higher tariffs available and/or the availability of tariff guarantees.	Applicant database
Feedstock type	The scoping calls indicated that the following categories of feedstock are utilised: • Farm waste • Energy crops • Sewage waste • Manufacturing/industrial waste • Municipal food waste Those who planned to utilise more than 50% energy crops in their plant would have been directly influenced by the reforms. In other cases, the impact of feedstock type on decision-making is less well understood at this stage.	There was no readily accessible source of data on this prior to the applicant interviews. It was considered that the applicant type (next row) is a more significant determinant in the decision-making process and that capturing a range of applicant types would automatically capture a range of feedstock types.

Applicant type	The scoping calls indicated that there are some distinct types of applicants and that the decision-making and business cases will be significantly different in each. The following typology was therefore developed:
	• Farm-based. The applicant is a farmer or a developer on a farm site, and the feedstock is agricultural (typically farm waste or energy crops).
	• Utility Company. The applicant is a utility company with their own feedstock (sewage waste).
	• Manufacturer or linked to a manufacturer. The applicant is a manufacturer, or subsidiary company, with their own feedstock (waste from the manufacturing process).
	• Developer. The applicant is a developer who may be developing multiple plants and may share equity in the schemes with:
	  ○ A feedstock supplier;
	  ○ A financier;
	  ○ A technology supplier (e.g. biogas cleaning/biomethane injection); and/or
	  ○ A landowner.
	A variety of feedstock may be utilised in such plants.
		The applicant database includes the applicant name and application company address. Research into the details of these enabled basic categorisation by applicant type for the purposes of sampling.
		Through the applicant interviews it became apparent that the categories were rather more complex than this, e.g. farm-based plants utilising more than just agricultural feedstock, or developers working closely with manufacturers on a manufacturing site.

Plant size	There is significant variation in the size of plant, which is likely to impact on the levels of investment risk and the nature and complexity of decision-making.	Applicant database
Type of grid connection	The scoping calls indicated that some schemes have been able to lower development costs by adopting different types of grid connection. Two types were mentioned: • Multiple plant with a single injection point • Plants with lower pressure injection point (a National Grid scheme was mentioned) The type of grid connection may have a bearing on the business case.	There was no readily accessible source of data on this prior to the applicant interviews so it was not possible to include it as a sampling criterion. Grid connection type was explored in the interviews
Development stage	The scoping calls confirmed the use of 'two-stage commissioning' in the pre-reform RHI and that some plants may not go beyond the first stage. Some of these plants may have reached the first stage of commissioning without having secured finance or feedstock for the scheme or addressed all of the necessary planning/permitting issues, and these may prevent the plant proceeding to completion. Two-stage commissioning might also be evidence in meter-readings for other cases (e.g. if early injection was required to test equipment, or if the initial installation was faulty and had to be stopped). With post-reform applications, two issues were identified:	Applicant database and admin database (for payments data)

	1. Achieving a tariff guarantee is challenging. Whilst this may serve to eliminate some of the more speculative schemes, it means that some will fail to secure the guarantee and be withdrawn or rejected. 2. The timescales for commissioning plant are challenging, which presents risks for applicants and may deter them from taking some plants through to completion.	

2.8 A flexible approach to the development of the sample had to be adopted, particularly because

- a significant number of applicants made multiple applications and we did not feel it appropriate to interview them more than once; and
- a significant number of applications were rejected, particularly in the pre-22 May 2018 part of the sample.

2.9 Table 2.2 provides details of the resulting sample for the applicant interviews.

Table 2.2: Sample details – applicant interviews

Sampling criteria	Pre-reform applicants	Post-reform applicants
Application date	7 applications from the period 15 December 2016 – 21 May 2018, of which:	11 applications from the period after 21 May 2018, of which:
Applicant type	• 1 was farm-based • 2 were utilities • 1 was a manufacturer, or linked to one • 3 were developers	• 4 were farm-based • 1 was a utility • 2 were manufacturers, or linked to one • 4 were developers
Development stage (at time of research)	• 2 had used 2-stage commissioning and were under construction • 2 had used 2-stage commissioning and were now fully commissioned • 1 had not used 2-stage commissioning and was fully constructed but awaiting final commissioning • 1 had not used 2-stage commissioning and was fully commissioned	• 7 had received tariff guarantee approval but were not yet commissioned • 3 were awaiting stage 2 tariff guarantee approval • 1 had received a tariff guarantee and was fully commissioned • 1 was fully commissioned but the RHI application related to a change of ownership

2.10 As can be seen in the table above, one of the post-reform cases sampled turned out to be an early 2016 application which was being re-registered with the RHI in May 2018 as a result of a change in ownership. The data from this case therefore had more limited relevance to our analysis. It did not readily relate to our theory as this was focused on the reforms. However, the data from the applicant interview was useful context and was used as far as possible.

2.11 In addition to the applicant interviews, interviews were sought with other stakeholders involved in the applications. The selection of these stakeholders was informed by discussion with the applicants – the applicant interviews included a question about the other most significant stakeholders in, or influencers of, the decision-making process for the plant in question. Interviews were sought with a range of stakeholders including investors/financiers, feedstock providers, landlords, gas shippers, an AD plant owner, gas network operator, digestate user, consultant advisers and technology providers.

2.12 Despite extensive recruitment efforts (as outlined below) we were only able to secure three interviews with other stakeholders involved in our sample of schemes:

- a gas shipper;
- a gas network operator; and
- a financier.

2.13 Following discussion with BEIS, we used the remaining interview time to:

- carry out a stakeholder mapping exercise, to better understand the range of stakeholders involved in the biomethane supply chain; and then to
- seek more general (non case-specific) interviews with stakeholder types who it was felt could add to our understanding of the biomethane market and the role of the RHI in it.

2.14 This led to us conducting six further interviews with the following types of biomethane stakeholders:

- the operator of an AD plant, supplying biogas to a separately owned biomethane plant;
- a digestate user;
- a digestate distributor;
- a food waste feedstock supplier;
- a biomethane technology supplier; and
- a biomethane injection plant owner.

Recruitment

2.15 CAG Consultants developed a recruitment process, agreed with BEIS. Recruitment involved the following stages:

- selection of sample to be contacted, and adaptation of the sample as recruitment progressed (as per the process described above);
- recruitment log developed to track communications to and responses from selected participants; and
- invitation email sent to applicants and stakeholders in the sample. The email outlined details about the study and what their involvement in it would entail. It also included a briefing note which provided information about consent terms, topics to be covered and interview practicalities.

2.16 The recruitment materials are attached separately in Appendix D.

Data collection

2.17 The research involved undertaking semi-structured in-depth telephone interviews with applicants in January and February 2019, and with stakeholders in March and April 2019. Interview length was approximately 45-60 minutes per interview for applicant interviews and 30-45 minutes for other stakeholder interviews.

2.18 Topic guides were developed for applicants and each of the other stakeholders. The topic guides were focused primarily on the demand theory being tested.

2.19 Interviewers attended briefing sessions on the policy and technical background to the research, as well as the use of the topic guides. Interviewers were encouraged to use the guides to explicitly test different propositions within the theory to test whether they applied, using the topic guide flexibly to achieve this outcome.

2.20 In advance of the interview, interviewers were provided with information about the applicant and application from the administrative data. This enabled the interviewer to have an informed conversation with the applicant and reduce time collecting information the applicant had already provided elsewhere.

2.21 The main topics covered in the applicant interviews were:

- Introductions and consents
- Application background, including feedstock, grid connection and stage of development
- Organisations and decision-makers involved
- Principal benefits of the business model
- The most significant elements of the business case for the installation
- The significance of the RHI in the business case
- The role of the RHI reforms in the timing of the application and the business case for the installation
- Final reflections
- Thank you and close

2.22 The main topics covered in the stakeholder interviews were:

- Introductions and consents
- Their role in the supply chain and the nature of their relationships with other organisations
- Principal benefits of their involvement in biomethane schemes
- The most significant elements of the business case for their involvement in biomethane schemes (if applicable)
- The impact of the RHI, and the reforms to the RHI, on their role
- Their views on the future of the market for biomethane
- Final reflections
- Thank you and close

2.23 The topic guides are attached separately in Appendix E: Fieldwork topic guides.

2.24 Interviews were recorded for research and quality assurance purposes, and then transcribed.

2.25 The interviews were conducted in confidence. No organisations or individuals are named in this report and some detail, including numbering of cases, has been left out in order to avoid the risk of indirect identification of respondents. Where there remains a significant risk of indirect identification, we have checked that the respondents are happy for this to be the case. Quotes and other references to specific sources are identified using the label BIOM (to identify them as a biomethane stakeholder) followed by the type of stakeholder, e.g. 'BIOM-Applicant', 'BIOM-Gas Network Operator' etc.

Analysis

2.26 The analysis employed both Dedoose, a Computer Assisted Qualitative Data Software Analysis (CAQDAS), and Excel spreadsheets. Dedoose was used to code interview transcripts[7] and other data sources, including application data and survey evidence. The coded material relating to the theory was then exported to Excel. A framework was created within Excel to further code and analyse the evidence against contexts, mechanisms and outcomes (C-M-Os) and the theory being tested.

2.27 We analysed the extent of support for different CMOs in the framework and the potential for refining existing, or developing new, CMOs (see Table 2.3 for an explanation of CMOs). The coding and analysis was undertaken by two researchers and was quality checked for consistency by another research team member not directly involved in the coding and analysis process.

Table 2.3: CMO glossary

Evaluation concept	Definition
Realist evaluation	A realist approach[8] to evaluation emphasises the importance of understanding not only whether a policy contributes to outcomes (which may be intended or unintended) but how, for whom and in what circumstances it contributes to these outcomes.
CMOs	Context-Mechanism-Outcome configurations. These are realist hypotheses about how the policy is expected to work, which are tested during the evaluation. See 'realist evaluation'
Context	The circumstances which affect whether a policy 'works' and for whom. Consideration of 'context' forms an important part of realist approaches to evaluation.
Mechanism	A change in people's reasoning, brought about through the resources provided by a policy, which leads to a policy outcome. Identification of causal 'mechanisms', which operate in particular 'contexts', forms an important part of realist approaches to evaluation.
Outcome	A change in the state of the world, brought about as a result of a policy or other influences. Realist approaches to evaluation attempt to identify the 'contexts' and 'mechanisms' that lead to a particular 'outcome'.

[7] Coding involved a process of indexing, sorting and categorising interview transcript data, by case and by theme, so that it could then be analysed.
[8] Pawson and Tilley (1997), Pawson (2006)

Limitations

2.28 Some limitations of the research are worth noting:

- As outlined in paragraph 2.12, our ability to conduct a 'case study' approach was constrained by difficulties in recruiting wider stakeholders in specific schemes. Accessing documentation about schemes also proved challenging, due to applicants' concerns about commercial confidentiality. This limited the depth to which we were able to explore individual cases. However, it was apparent in all of the applicant interviews that the interviewees were the principal decision-makers for their schemes and in all cases, interviewees were able to talk about all aspects of their schemes in depth. A benefit in conducting wider stakeholder interviews was that we were able to gain a wider understanding of the market.
- Our research was exclusively focused on the reformed RHI, i.e. the RHI which was available to biomethane applicants from 15 December 2016 onwards. The significance of these reforms mean that the findings will be of limited benefit in understanding the role of the pre-reform RHI.
- Each of the interviewers had extensive briefing prior to the fieldwork but the heterogeneity and complexity (in terms of technologies, the supply chain and he diversity of stakeholders involved) of the market meant that our understanding of the market built and evolved as the research progressed. Later interviews benefited from this, meaning the depth and clarity of the evidence generated will have improved as the fieldwork progressed.
- Given the heterogeneity of the market, understanding the variety of contexts for biomethane investment was challenging and it is likely that some contexts will have been missed or not fully explored and, inevitably, the findings represent generalisations to one degree or another. However, a relatively large sample was incorporated in the research (approximately 36% of all applications submitted after 15 December 2016 were included in our sample), which gives us confidence in the robustness of the conclusions drawn.

3 Influence of the RHI on biomethane investments - overview

Candidate and observed CMOs

3.1 Our candidate CMOs are summarised in the sub-sections below and presented in more detail in Appendix B. These CMOs were closely based on CMOs 1, 3, 4, 5 and 6 in the overall demand theory for the reformed RHI. There is no biomethane equivalent to CMO2 in the overall demand theory, as this relates to the rebound effect for renewable heat which is not directly relevant to biomethane. As in the overall demand theory, these CMOs focus on whether the reformed RHI contributed to change that would not have happened without the RHI. In other words, these CMOs focus primarily on distinguishing between different ways in which the reformed RHI may or may not have generated 'additional' outcomes for biomethane installations.

General contexts

3.2 As noted in paragraph 1.23, it was assumed in the candidate theory that a relatively complex set of general contexts (or requirements) would normally need to be in place for any biomethane investment. This was confirmed in the research and the general contexts which were observed in the research are shown in Table 3.1.

Table 3.1: General contexts for biomethane developments

General contexts for biomethane
Access to financially viable injection point (a function of distance, pipeline pressure, capacity, approval speed)
Access to land (typically leased in the case of developer applications & owned in the case of others)
Planning permission and relevant environmental permits secured
Cost-effective access to appropriate technology
Access to appropriate electrical supply (from grid and/or associated CHP)
Access to cost-effective internal or external finance
Cost-effective access to feedstock supply which meets post-reform requirements
Cost-effective outlet for digestate (income from digestate sales is rare and never a significant income stream)
For applications after 22 May 2018, a business case which was not reliant on digestate drying (note that this does not mean that no digestate drying is incorporated in plants)

3.3 The general contexts were applicable to all cases in our sample and underpin each of the CMOs. Further discussion of these contexts can be found in section 5. A range of other contexts have been identified which are specific to the individual CMOs discussed below. These are discussed further in section 4, where we describe each CMO in detail.

Candidate CMO1a – Reformed RHI contributed to a viable business case for this proposed biomethane installation - not viable without the reformed RHI

3.4 This CMO describes cases in which the business case for the biomethane installation would not have been considered to be viable prior to the reforms but was so after the reforms. It was commonly encountered in the fieldwork. However, it masked some significant differences between cases. For example, significant differences were observed between applicants of different types and in terms of which aspects of the RHI reforms were significant. It has therefore been replaced with a series of more specific observed CMOs, as shown in Table 3.2.

Candidate CMO1b – Pre-reform RHI contributed to a viable business case for this proposed biomethane installation - not viable post-reform

3.5 This CMO was not observed because our sample was solely focused on post-reform applications. However, we have retained this CMO in our theory because the data indicated the presence of cases in which the reforms negatively impacted schemes reliant on crop feedstocks which were being planned at the time of the reform announcements and which could not be adapted to meet the new feedstock restrictions. One developer referred to a number of such schemes having to be abandoned, which had had a very negative impact on their business.

It [the changes to feedstock rules] has meant that other schemes that we had spent five-figure sums on became unviable overnight. Therefore, we had to walk away from a lot of those projects, which is part of the negative effect it's had on our business. But, yes, when it became clear that you would have to achieve at least 50% of your gas production from waste materials, then the agricultural schemes that we had been developing until that point became unviable. So, all the ones that couldn't be repurposed… I mean, we're a small company, we employ some people. It very, very nearly bankrupted us. (BIOM-Applicant)

3.6 Others suggested that tariff degressions had led developers away from crop-based schemes and towards cheaper waste-based feedstocks, and that the rule changes may not have even been necessary. This indicates that the feedstock rule changes may not have been solely responsible for planned crop-based schemes becoming unviable.

They [the feedstock rules] make you – they force you to look in certain directions but economics also causes you to look in certain directions. Grown crop feedstocks do come at a cost so there are good reasons to avoid grown crops to reduce your overheads if you can find other food stocks that work… Just the tariff coming down, it pushes you away from that [reliance on crops] a bit because you want to try and get cheaper feedstocks anyway in order to make the economics stack up. So I think economically speaking, you'd still have plenty of incentives. I think having a hard rule is a blunt instrument and I think actually, cold economics would have pushed people in the direction that policy wanted it to go anyway. (BIOM-Applicant)

Candidate CMO1c – RHI contributed to a viable business case for this proposed biomethane installation – not viable without the RHI, but the reforms were not a major influence

3.7 This CMO was observed in our sample but only in the case of a specific type of applicant – manufacturers with a waste product which provided a secure feedstock supply, so the CMO has been revised as shown in Table 3.2.

Candidate CMO2 – Irrespective of RHI, there was a viable business case for this proposed biomethane installation – RHI was a windfall

3.8 This CMO was not observed in our sample. Given the evidence gathered regarding the scale of importance of RHI income in the business cases, we do not think that such cases existed at the time of this research. This CMO has been deleted from the theory.

Candidate CMO3 – Pre- or post-reform RHI improved the business case for this proposed biomethane installation but it might have been viable anyway

3.9 This CMO is similar to CMO2, but encompasses cases where the role of the RHI in the business case was sufficiently marginal that the applicant felt there was a possibility of the installation being viable without the RHI. As with CMO2, given the evidence gathered regarding the scale of importance of RHI income in the business cases, we do not think that such cases existed at the time of this research. This CMO has been deleted from the theory.

Candidate CMO4 – The technology choice, feedstock choice, scale or investment timing of this proposed biomethane installation was influenced by the pre- or post-reform RHI

3.10 This CMO was observed alongside some of the other CMOs. The principal ways in which the RHI influenced the installations were:

- delaying RHI applications in order to access the tariff guarantees;
- speeding up RHI applications in order to avoid an anticipated rush of applications after the reforms were implemented;
- removing digestate drying from the planned installation; and
- adjusting the size of the installation to avoid reliance on the reformed tariffs for tier 2 and tier 3 production.

Candidate CMO5a – the business case for this proposed biomethane installation is still not viable despite the reformed RHI (i.e. other factors mean that this project is still not viable)

3.11 This CMO was not observed, as all of the installations in our sample had made applications to the RHI and were therefore likely based on viable business cases. However, we have retained this CMO in the theory as we did encounter evidence of such cases in our wider stakeholder interviews, including one stakeholder (an AD and biomethane developer and operator) who referred to having developed three projects for funding but had been unable to achieve financial close because the reset tariff levels were insufficient to secure the necessary external finance.

At the current RHI rates, we're not building any plants, and we developed 3. So, we spent the best part, in fact probably over £500,000 getting 3 projects ready for funding, and we haven't managed to get any of those to financial close under the current regime of the RHI. It's not, in our view, enough to run a plant. (BIOM_AD_Operator)

3.12 We have limited evidence regarding the factors which differentiate between those developers who were able to achieve viable business cases and those who were not, so this CMO is not covered in depth in the report. However, the interviewee quoted above indicated that a factor in their case may have been an unwillingness to compromise on operational costs. This was partly due to their operational role in the plants they develop and their reliance, therefore, on

the income from performing this role. Their previous operational experience was also said to have indicated a need for proper investment in operations in order to ensure consistent output from AD.

3.13 The same interviewee also suggested that a number of developers who perceived their business cases to be viable may go on to discover that they were not, either before or after plants were commissioned. The interviewee speculated that as many as 50% of plants which have achieved tariff guarantees may not achieve financial close and that others may experience financial difficulties post-commissioning. An upgrade plant supplier who was interviewed similarly estimated that 50-60% of plants that had achieved tariff guarantees would not be commissioned, partly due to bottlenecks in the supply chain brought about by the January 2020 deadline for commissioning.

3.14 We encountered a significant number of plants in our sample which may well not be commissioned because of risks/uncertainties associated with meeting the January 2020 deadline for tariff guarantee installations. These issues are discussed further in section 6.

Candidate CMO5b – the business case for this proposed biomethane investment is still not viable, despite being approved for pre-reform RHI, and it's unlikely to go ahead

3.15 As with CMO5a, this CMO was not observed because such applications were not included in our sample, i.e. all applications were in post-December 2016. It may be possible to explore the extent to which this CMO is valid during the synthesis work, using data from the quantitative workstream.

Table 3.2: Revisions to theory

Candidate CMO	Revised CMO	Observed (Y/N)
CMO1a – Reformed RHI contributed to a viable business case for this proposed biomethane installation - not viable without the reformed RHI	**CMO1a -** Developers seeking short-term profit from investment in biomethane, who had a relatively insecure and costly feedstock supply (fully or partly food waste) and had external equity-based or high-cost debt finance. They were therefore reliant on the uplifted tariffs, and the reduced investment risk offered by tariff guarantees, to achieve a fundable business case.	Y
	CMO1b - Developers linked to, or part of, companies with wider long-term business drivers for biomethane development, who were utilising either the proven biogas supply from existing AD plants or access to a secure local feedstock supply to achieve a viable business case with the uplifted tariffs. Access to internal finance and the wider business imperatives, however, meant these developers had no need for the de-risking provided by two-stage commissioning or tariff guarantees.	Y

Candidate CMO	Revised CMO	Observed (Y/N)
	CMO1c – Developers with access to a secure feedstock supply, who were reliant on the uplifted tariffs to achieve a viable business case. They did need to de-risk their investment through securing their tariff as early as possible, but their funding arrangements meant they were able to do so using two-stage commissioning rather than tariff guarantees.	Y
	CMO1d - Developers with a secure feedstock supply, who were reliant on the uplifted tariffs to achieve a viable business case and using tariff guarantees to facilitate access to external finance. Some such plants, however, may have been able to proceed without these guarantees.	Y
	CMO1e - Farmer applicants with a relatively secure feedstock supply, access to low-cost debt finance, and wider environmental and business drivers for biomethane/AD, utilising the uplifted tariffs and reduced investment risk offered by tariff guarantee. [The data is unclear as to whether the uplifted tariff and tariff guarantees were necessary to achieve a viable business case].	Y
	CMO1f - Water companies with a secure feedstock supply and existing biogas generation, who were relying on the uplifted tariffs and utilising either tariff guarantees or two-stage commissioning to reduce investment risk and achieve a fundable business case with internal finance.	Y
CMO1b - Pre-reform RHI contributed to a viable business case for this proposed biomethane installation - not viable post-reform	Retained - Re-numbered as **CMO2**	N
CMO1c – RHI contributed to a viable business case for this proposed biomethane installation – not viable without the RHI, but the reforms were not a major influence	**CMO3** - Manufacturing companies with a secure feedstock supply, which were reliant on RHI and benefited from the reforms but had a viable business case, irrespective of the reforms, due to wider business imperatives and access to internal finance.	Y
CMO2 – Irrespective of RHI, there was a viable business case for this proposed biomethane installation – RHI was a windfall	Deleted	N
CMO3 – Pre- or post-reform RHI improved the business case for this	Deleted	N

Candidate CMO	Revised CMO	Observed (Y/N)
proposed biomethane installation but it might have been viable anyway		
CMO4 – The technology choice, feedstock choice, scale or investment timing of this proposed biomethane installation was influenced by the pre- or post-reform RHI	Retained - No revisions	Y
CMO5a – The business case for this proposed biomethane installation is still not viable despite the reformed RHI (i.e. other factors mean that this project is still not viable)	Retained - No revisions	N
CMO5b – The business case for this proposed biomethane investment is still not viable, despite being approved for pre-reform RHI, and it's unlikely to go ahead	Retained - No revisions	N

Overview of observed CMOs

An overview of the observed CMOs is shown in Figure 3.1. An equivalent diagram for each individual CMO is included in each sub-section of section 4.

3.16 It should be noted that our theory relates exclusively to the reformed RHI, i.e. the RHI which was available to biomethane applicants from 15 December 2016 onwards. Other CMOs would be applicable to pre-reform RHI applicants.

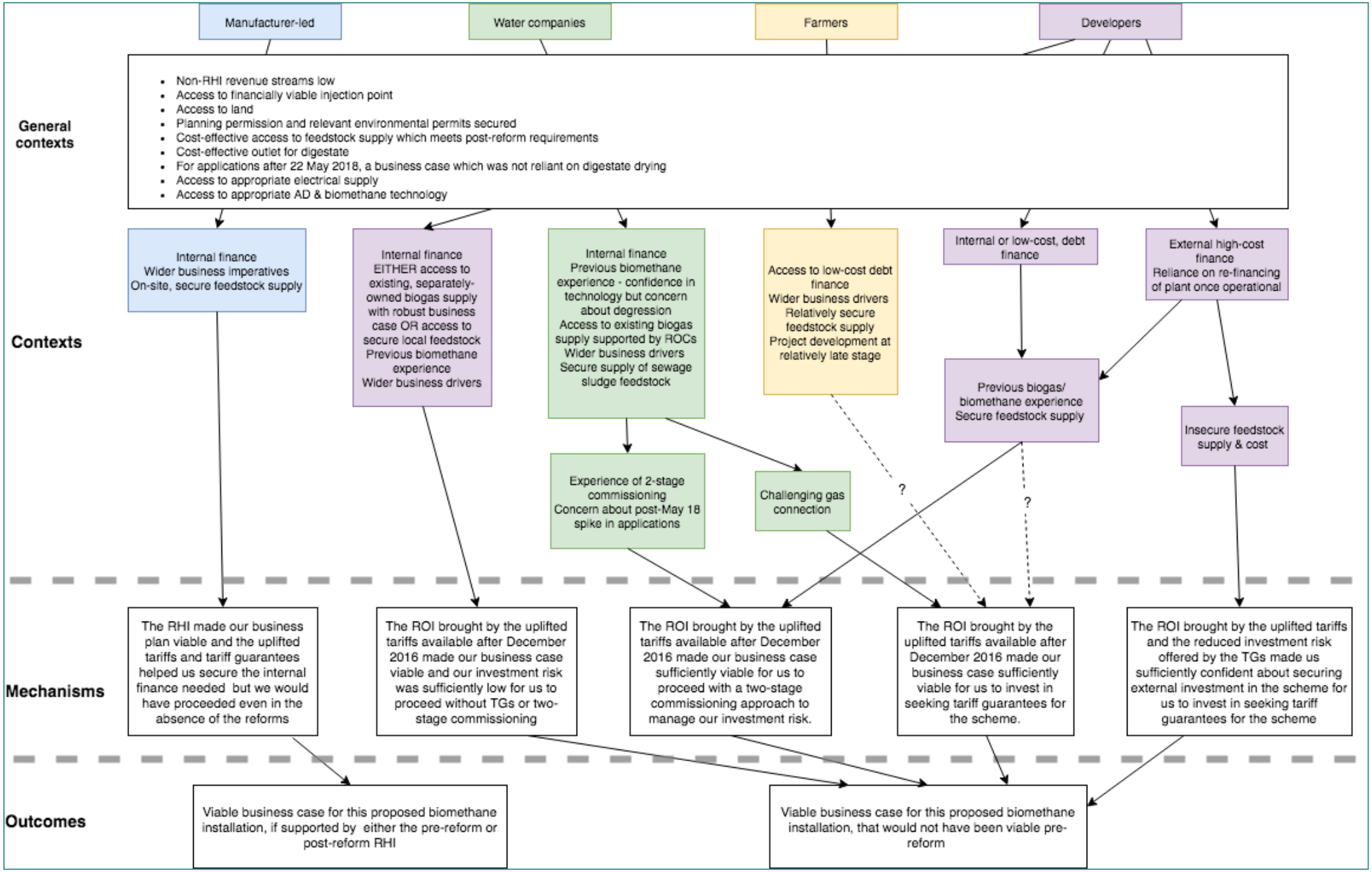
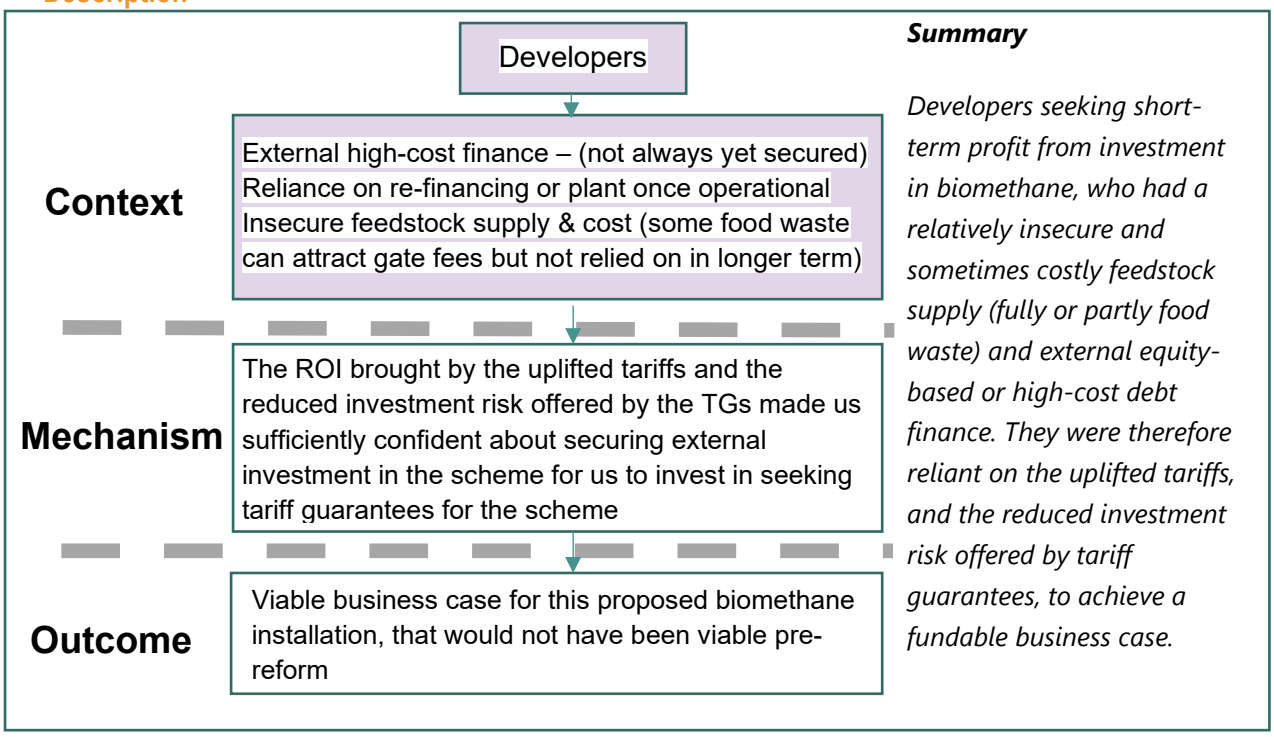


Figure 3.1: Observed post-reform RHI biomethane CMOs - overview

4 Influence of the RHI on biomethane investments - detail

CMO1a – Speculative developers

Description



4.1 The applicants were developers who had either secured or were seeking to secure external finance in the form of equity investment or relatively high-cost debt finance, with a view to selling or refinancing the plant once it was proven to be productive.

4.2 The applications were not directly linked to feedstock sources, i.e. they were not being developed in conjunction with a farm, manufacturing plant or sewage treatment works, but instead were reliant either fully or partly on the market for food waste. They were typically incurring a cost for the feedstock and could only secure relatively short-term supply contracts (typically 1-2 years).

4.3 The high cost of finance or high ROI required by equity investors, coupled with the relatively insecure and costly feedstock supply, meant that these cases were only viable under the reformed RHI. They were reliant on both the uplifted tariffs to achieve the necessary ROI and the reduced investment risk offered by tariff guarantees to achieve a fundable/investable business case.

"The reformed one did two things. One, it gave a higher tariff which meant that you can have commercially viable projects out there. And secondly, it created a process where you could have certainty and go to funders and say, "This is what we have. This is how commercially viable a project it is." It wasn't a case of, "Let's build it and we might get this." (BIOM- Applicant)

Discussion of key contexts observed

4.4 Various types of external finance were observed in this CMO, including both equity and debt finance, and with various business models including:

- A developer which had not yet secured their finance but had proceeded on the basis that they may not have equity in the scheme and may simply profit from delivering the scheme and operating it on behalf of an investor.
- A developer with an external equity investor but who retained a majority equity stake and were outsourcing the development and operation of the plant.
- A developer structured as a Special Purpose Vehicle incorporating various specialists (e.g. construction, feedstock) reliant on high-cost debt finance.

4.5 In each case, the schemes were being pursued on the basis that they would be sold or re-financed once operational and proven. Further research indicated that such schemes would typically be re-financed through a loan from a mainstream bank or sold on to a pension/investment fund. It was apparent that the schemes may represent considerable risk until that point. One participant suggested that this had been exacerbated by the delays to the RHI reforms and subsequent delays in securing tariff guarantees, which had increased their costs and that, in that time, feedstock costs had also increased.

All that [delay] has cost us a lot more money which has put a lot more pressure on the project because we've had to borrow more money. And then we spent- with the cost of feedstock going on, right, cost of waste food, it's more and more expensive and the reduction in the RHI has made it very, very tight commercially, which it should be. It's still commercially viable but with the funding arrangements now we have to borrow more than what we should have….[It] puts more pressure on- and it's just for the next three years or for three years until the project is flipped to a debt funder, it's going to be so, so difficult and end up maybe like other projects where the funders win. Ultimately we fail, default in making a payment back because we just can't get the plant ramped up or get the feed stock, and any margin of error we had was gone and the funders nip in and they have flooding rights and they take over the company. They take you up as directors. You become minor shareholders and they do what they want with it. (BIOM-Applicant)

4.6 Although these developers were utilising external finance, this finance was only available once the tariff guarantee had been secured and it may also have been necessary to secure feedstock contracts (discussed further below). This necessitated considerable up-front investment on the part of the developers. One applicant referred to having invested 'tens of thousands' in getting to that stage.

4.7 A further key feature of these applicants was that they were reliant on securing food waste as a feedstock. At least one business case was said to be reliant on securing a gate fee for this waste and were concerned about the extent to which this was going to be achievable, whilst others were anticipating feedstock being a cost.

4.8 Security of supply was a further issue, with applicants struggling to secure long-term contracts for supply, particularly as most companies were said to be unwilling to commit to any contracts

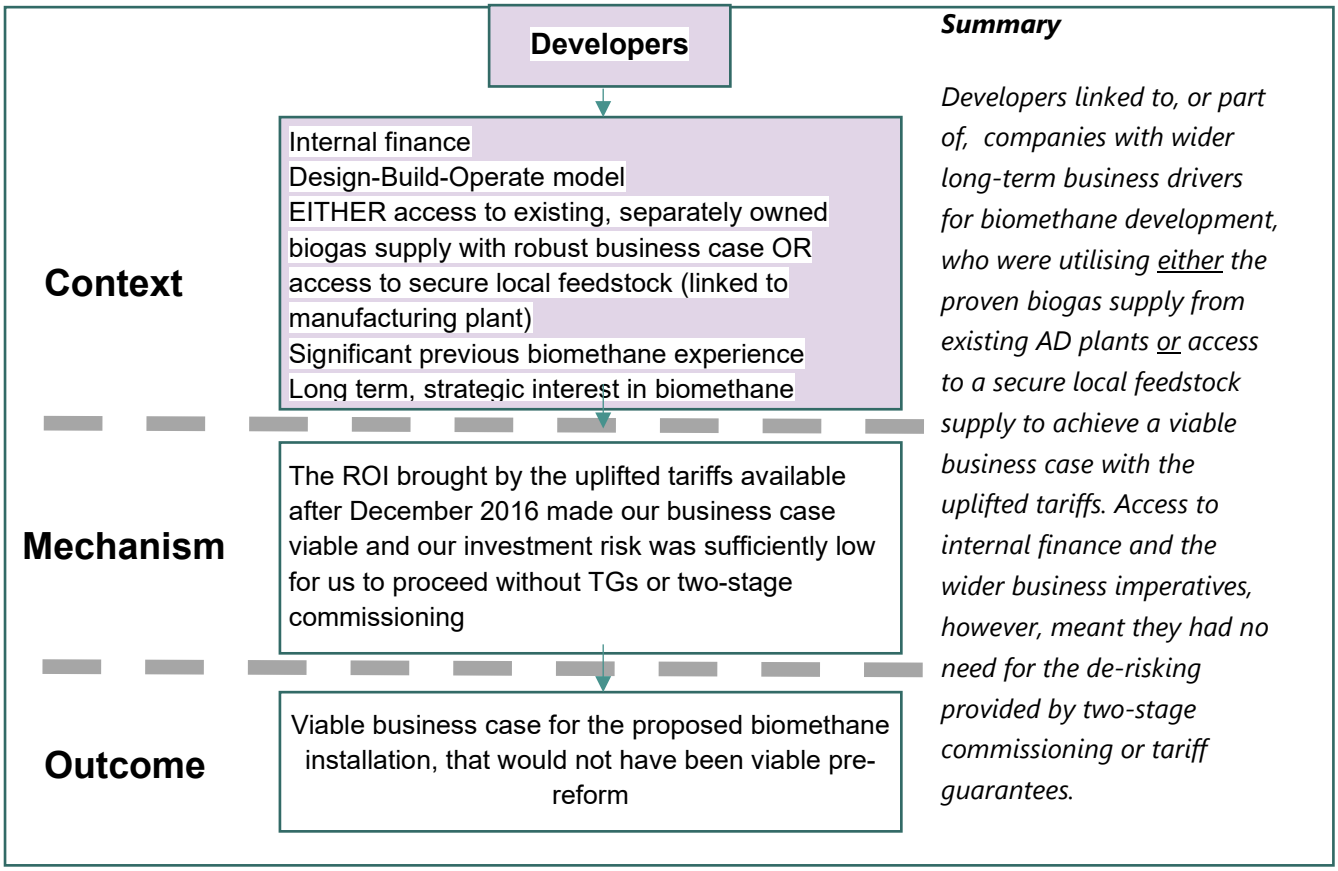
on the basis of an as-yet unbuilt plant. In some cases this was hampering their efforts to secure external funding, although the evidence suggests that some funders were more flexible than others.

4.9 Applicants were seeking to address the risks associated with this feedstock in various ways. One was planning a varied feedstock with diverse supply lines, including agreements to take farm waste with local farmers, an agreement with a local composting site and a contract with a food waste broker. Another was seeking to establish their own food waste collection service.

4.10 Nevertheless, this relative insecurity of feedstock, in both supply and cost terms, further reinforced the applicants' need for the higher potential returns and de-risking of investment brought by the uplifted tariffs and tariff guarantees.

CMO1b – Design-Build-Operate developers

Description



4.11 The applicants were developers who were subsidiaries or parts of large companies with a long-term interest in biomethane development. This might stem, for example, from those companies generating waste which is suitable as a biogas feedstock or from them having a wider presence in the biomethane supply chain.

4.12 As with CMO1a, the improved ROI brought by the uplifted tariffs was critical to making the business cases for these schemes viable.

The reform was important because the tariff that was on offer pre the reform was unviable. If the tariffs hadn't been reset to 5.6p a kW, [Parent company name] wouldn't have proceeded with the plant. It was only at the point that we got comfortable that the tariff was going to be reset to 5.6 a kW did we proceed, if you see where I'm going. The actual tariff, before the reform happened, was lower than 5.6p per kW. (BIOM- Applicant)

4.13 The same applicant indicated that uplifted tariffs were only just sufficient to satisfy their internal funding requirements and that they proceeded partly on the basis that they could improve their profitability in future. While securing long term contracts for feedstocks, or biogas supply, gave these applicants certainty, it did minimize their ability to change their profitability in future.

It was very borderline, yes, absolutely. To be honest with you, the returns that we're making off the plant are probably slightly below the expectation of the board. We have taken a risk with a view that, maybe, one day we can improve the P&L [profit and loss] through improving processes, reducing costs of elements that you can impact and affect still. Feedstock is something that we can't affect now, we have a 15- to 20-year contract in place. That cost is there. We will look to see if we can improve areas such as digestate, maybe improve the processing, improve… Maybe even reduce the labour bills on site and stuff. We don't know, but we have almost, basically, taken a punt and agreed that we will try to improve the P&L through cost savings in the future. (BIOM-Applicant)

4.14 However, there was no need for the de-risking of investment provided by the two-stage commissioning process or the tariff guarantee process. The schemes did not have external funders to satisfy as they were funded internally or by a parent company (who had a strategic commitment to biomethane development) and the developers had confidence in their ability to deliver the plants borne from their previous experience of similar developments and, crucially, their ability to either access a secure feedstock supply or add biomethane upgrading equipment to an existing, proven biogas supply.

When we built this site, we were confident that we could build it within a timescale in which we wouldn't actually need to rely on the tariff guarantee. It was, effectively, built before the tariff guarantee rules became live… The introduction of the tariff guarantee didn't feature in the assessment on this plant, no, absolutely not. (BIOM- Applicant)

Discussion of key contexts observed

4.15 The absence of any reliance on external funding was a key factor in these applicants being able to proceed without having to wait for a tariff guarantee.

So [company name] has this advantage of self-funding everything that we develop. We have, we have a funding system within the group, which entitles us to ask for funding within the company. So everything that we operate is actually owned by [company name] 100%. (BIOM- Applicant)

4.16 Specific details on how internal funding requirements and costs compared to external funding requirements and costs were limited. However, one applicant referred to the need to achieve a 12% rate of return, which is lower than some of the rates quoted by those reliant on external

sources. Those with access to internal funding recognised that they were in an advantageous position.

We haven't gone external for funding here. We have an arms-length loan agreement, arrangement, with the parent company which we obviously have arrangements to pay back. There is also an interest rate that is charged on that, but it's not been an external third party. It's via the parent company, that is. That's the financing of the plants. We probably do benefit a little bit, from that perspective, compared to some of the other entrants in the market. (BIOM-Applicant)

4.17 The developers were operating a design-build-operate model for their plants and in one case were also supplying their own technology. This in-house approach, and the previous experience gained from earlier plants, was a further key factor in the applicants being able to manage their costs and having the confidence to proceed, without the need for the de-risking provided by two-stage commissioning approach or tariff guarantees. This enabled them to proceed with development as soon as the uplifted tariffs became available in December 2016.

4.18 Where feedstocks were needed by the developer, this was not necessarily all secured from their own business but could be supplemented from other sources, i.e. the developer was not simply seeking a solution to their own waste generation.

4.19 The role of feedstocks in the business case varied. One developer who was a waste food collector reported being able to charge gate fees for their feedstock and suggested that their business case relied on this. The same developer reported being able to generate some income from the sale of digestate. This had required the achievement of BSI PAS110[9] for their AD plant and considerable work to develop the supply chain for the fertiliser.

4.20 In other cases, even though the contract for feedstock supply was long-term, there was a cost attached to both feedstock supply and digestate disposal. Feedstock costs could be putting pressure on the business case in such cases.

The [company name] model, unfortunately, we have to pay for feedstock, which is ultimately a fairly damning part of the financial model compared to a wastewater treatment plant or a sewage company… From a feedstock perspective, they [the costs] are fixed in the sense that we have a base price and the contract agrees to inflate the price in comparison with CPI each year. We have had to bear that in mind. Because the RHI attracts CPI as well, we feel that the model cannot get any worse from that perspective. That's why we offered that to the suppliers.

It's difficult because suppliers in the industry are reluctant to commit to 20 years because they are also sitting there thinking, "I don't know. Our feedstock, today, might be worth X pounds per tonne. It might be worth a lot more in 5, 10, 15, or 20 years." So it's difficult to get anybody to

[9] The industry specification for AD digestate, against which producers can verify that they are of consistent quality and fit for purpose. It covers all AD systems that accept source-segregated biowastes.

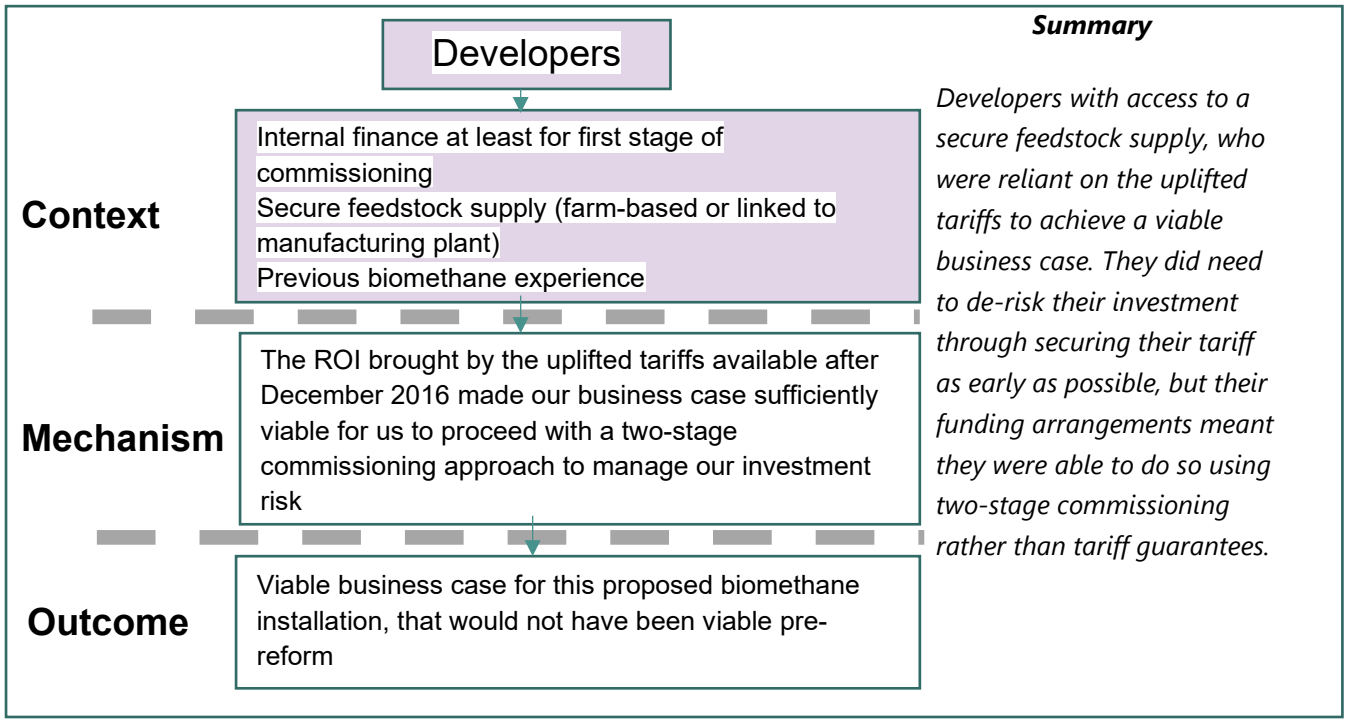
commit for 20 years, to be honest with you, so we had to offer something of that nature that allows some sort of inflationary increase to the price of feedstock. (BIOM- Applicant)

4.21 This variability in the nature of the business cases indicates that the requirements attached to internal finance are also likely to have varied significantly, i.e. those with income from gate fees and digestate sales may have been able to meet more challenging requirements for the financing of their schemes.

4.22 Where the developer was utilising a biogas supply from an existing AD plant, there was evidence of considerable work to ensure that the supply would be robust, with reference to extensive due diligence being carried out in relation to aspects such as funding of the plant and feedstock supply.

CMO1c – Developers with internal finance

Description



4.23 This CMO and CMO1d are similar to CMO1b in the sense that the applicants had access to secure feedstock supplies, which helped to de-risk the investment, and were similarly reliant on the uplifted tariffs to achieve a viable business case. However, the key difference was that the applicants fitting CMO1c and CMO1d needed to further de-risk their investment either through the use of the two-stage commissioning process (CMO1c) or through securing a tariff guarantee (CMO1d).

4.24 A number of factors may have driven the distinction between the cases which sought to lock-in their tariff early and those which did not, including the presence or otherwise of wider business drivers for biomethane development (all those in our sample who proceeded without two-stage commissioning or tariff guarantees had strong such drivers, as described in CMO1b) and the level of confidence and capacity to deliver schemes quickly.

4.25 We do not have extensive data on the costs of reaching stage one of a two-stage commissioning process (and therefore securing a RHI tariff) versus the costs of securing a tariff guarantee, but the data we do have indicates that the latter was significantly less expensive. One applicant indicated that they had spent c£2 million to reach stage 1 of the commissioning process, compared to the 'tens of thousands' referred to by another applicant for reaching stage 2 of the tariff guarantee process.

4.26 With these cost differences, it is perhaps unsurprising that the source and type of finance appears to have been a key factor in determining whether the applicant was able to pursue the two-stage commissioning route, rather than wait for a tariff guarantee, i.e. the finance arrangements needed to allow for the possibility of investing in the first stage of commissioning at risk. This is discussed further below.

4.27 A further factor in the choice between two-stage commissioning and tariff guarantees was the timing of the scheme. Some schemes were already relatively advanced at the time of the reform announcements but hadn't yet secured their tariff, so it made sense for them to continue pursuing a two-stage commissioning approach rather than wait for the tariff guarantees to be implemented.

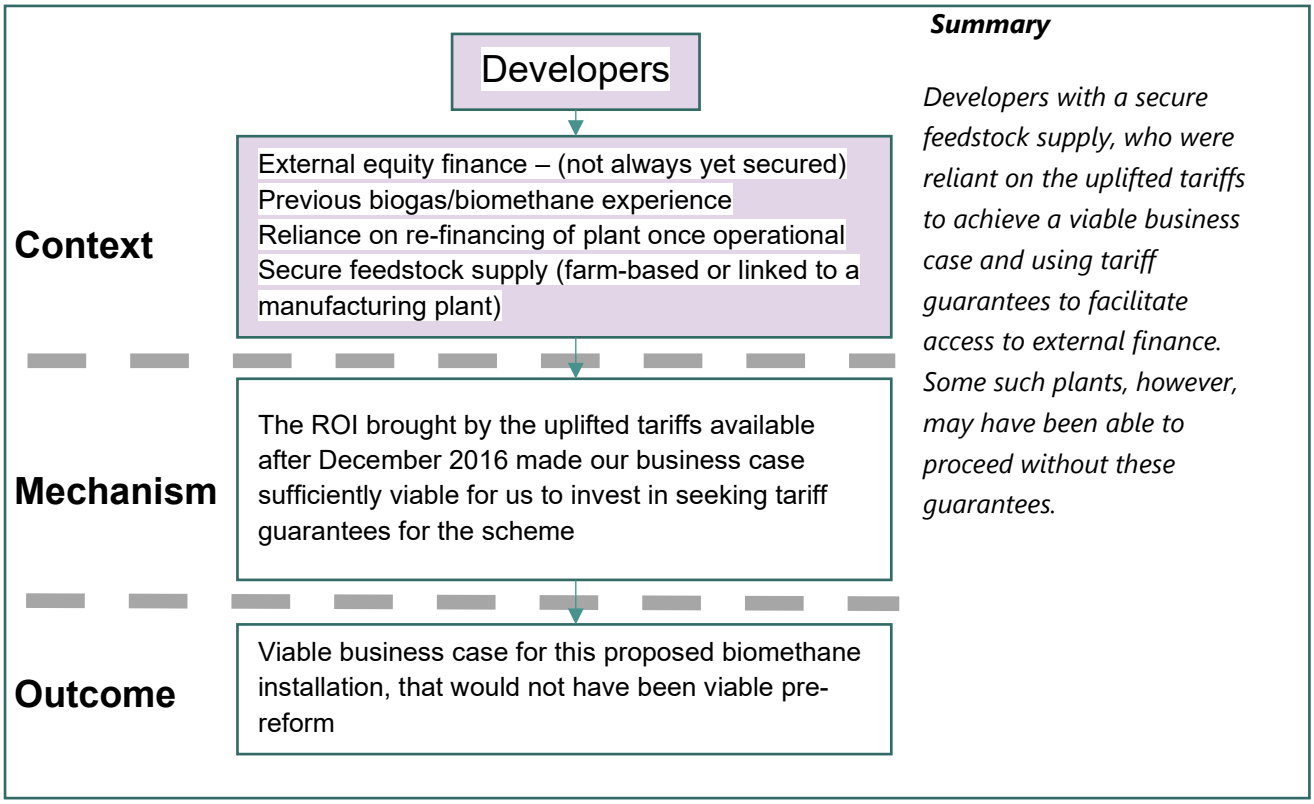
Discussion of key contexts observed

4.28 As noted above, the source and type of finance appears to have been a key driver in determining whether applicants pursued a two-stage commissioning approach or waited to try and secure a tariff guarantee. Some applicants from other CMO types suggested that they could not have secured finance for their schemes without a tariff guarantee in place. In this CMO, applicants were able to secure finance on the basis of a two-stage commissioning approach. Although internal finance was most commonly encountered, we did encounter a case which fitted this CMO, where external finance was being utilised. The reasons for their funder being comfortable with a two-stage commissioning approach are not entirely clear from the data. This particular applicant, however, appeared to have been able to do at least some of the work required to secure the RHI tariff with their own funding, which meant that they were able to secure cheaper finance. They also had an extensive track record of delivering biomethane plants through the two-stage commissioning route and an established relationship with the funder.

4.29 A secure feedstock supply further reduced the investment risk associated with this CMO. This could be achieved through, for example, securing long-term contracts for feedstock supply with farmers. In one example, it was more of a perception of the supply being secure - no long term feedstock supply contracts were in place, but the developer had sited the plant in an area where alternative higher value crops were not considered to be feasible and proximate to a number of food waste producers, from which feedstock was being sourced.

CMO1d – Developers with secure feedstock supply

Description



4.30 As with CMO1a, the high cost of external finance (in one case fitting this CMO, the funder was reported to be requiring 17% ROI) associated with most of these cases meant that the uplifted tariff was critical to the business case in most cases. An exception to this was a case in which low-cost finance was secured against the wider assets of the company, which meant that the importance of the uplift in tariffs was less clear-cut.

Yes. I mean, we could have done [gone ahead without the uplifted tariff]. Whether or not the client would have accepted the ROI, I don't know. We knew the uplift was coming. (BIOM-Applicant)

4.31 Some of the plants which fitted this CMO only had viable business cases on the assumption that the plants could be sold or re-financed once the plant was proven to be productive.

At 13% [interest], which is where I am, I think you would struggle to pay back capital and interest over the 20 years. There would be zero dividends and you would probably… By the time you'd serviced your debt, you wouldn't fully repay the capital that you'd borrowed. This is purely about facilitating the build, somebody taking the really high-risk finance to build it, get it commissioned,

get it operating… Before year 5 of operations, when there is 15 years left on the long-term, you then flip it to keep the money. At that point you have 15 years, then you probably put a 10 year repayment loan in place. You then pay back, over the next 10 years, because you're only paying 5% or 6% rather than 13%. You pay that back over the next 10 years on a repayment plan. Then there are 5 years at the back end where, if all goes well, there is a potential for a return for the equity holders in the project. (BIOM- Applicant)"

4.32 As with CMO1c, although these applicants had a secure feedstock supply, they needed to further de-risk their investment through securing their RHI tariff prior to commissioning the plant. In these cases, the applicant waited for tariff guarantees to become available (in May 2018) and this appears to have been driven largely by the fact that they were reliant on external finance. As described in the previous section, the costs associated with reaching the first stage of a two-stage commissioning approach appear to have been significantly greater than the costs of securing a tariff guarantee. The business case for tariff guarantee applications was further enhanced by the fact that a two-stage commissioning approach resulted in the loss of some RHI payments, since the 20-year payment period commenced prior to the plant being fully commissioned.

You, basically, are losing part of your 20-year income that pays back against the debt of the project, so while it's great because it locks in that subsidy and it's something that I recommend, it does actually mean that if you do it very quickly, you've basically got then a period, while you build at leisure, where you're not getting any income and it's just eating into your overall 20-year payback against the project. (BIOM- Applicant)

4.33 However, the necessity of the tariff guarantee was not as clear in all cases as it was in relation to CMO1a. Some of the applicants had previously developed similar schemes prior to the availability of tariff guarantees and one applicant suggested that, had the tariff guarantee not been available, financiers may have been willing to proceed under a two-stage commissioning route, i.e. it may have been preferable rather than essential in some cases.

4.34 Another applicant indicated that they were seeking to develop a plant without a tariff guarantee (and with the January 2019 tariff) at the time of the research, although they had yet to secure funding for it.

So I'll have to find out what the appetite of my funder is for any non-tariff guarantee projects. I assume they'll want to stay in business funding AD plants but I don't know. (BIOM- Applicant)

4.35 As noted with previous CMOs, the applicants still had to risk significant amounts of their own money to develop an investable proposition.

It's just been… you invest all that money in the submissions. The planning application costs, easy a hundred grand when you've got all the different consultants reports and things like that. Then you have lawyers' fees and this, that and the other. You've soon spent an awful lot of money and no way- Until actually you can get the go-ahead to start construction, there is no way of any money coming back into the company. (BIOM- Applicant)

Discussion of key contexts observed

4.36 Securing external funding was described as being challenging, with many funders viewing this type of investment as too risky.

I mean, before we got to [company name], we would have spoken to 15 investors, of which over 10 of them have got out of the AD market, or are only buying up operational assets… Funders just see the risk of AD as being too high. (BIOM-Applicant)

4.37 Previous biogas or biomethane development experience was a characteristic of all applicants and is likely to have been a factor in them being able to secure finance. Security of feedstock supply also helped to de-risk these cases and was important in enabling the plants to proceed.

There were critical negotiations [with the feedstock supplier] that were going on from the outset. There is no point in designing it- You take some risk. You're not going to be certain of all of your feedstock, when you submit your planning application, but you need to feel that is an achievable goal… Obviously any funding application is a gamble. You've got to be comfortable that feedstock is an achievable deal. (BIOM- Applicant)

4.38 This security of supply was typically achieved through co-locating the plant with a feedstock source, such as a farm, food waste transfer station or manufacturing plant. This also meant that in many cases, proximity and efficiency of feedstock supply (and related lower costs) were a further benefit in terms of the costs of the scheme.

So, for a period of time, the intention has been to co-locate with the waste transfer because the waste transfer site currently sells soup to a number of AD plants. So, having the facility onsite is simply to have the most efficient process under one roof, effectively. (BIOM- Applicant)

4.39 However, there were different degrees of security of supply. Some had supply contracts for the life of the plant but others did not. For example, in one case the landlord was the feedstock supplier so had a vested interest in providing a secure supply to the plant but a long-term supply contract was not in place.

4.40 Achieving this security of supply, in some cases had presented challenges in terms of the length of the project development phase. One applicant had gone through the process of purchasing a food waste transfer station, on which their plant was being developed. In another case, the developer was developing on a brownfield site and this involved significant site preparation works. Meeting the January 2020 deadline for tariff guarantee applications was particularly challenging in such cases.

It's especially hard for us because we're on a brown fieldsite, which is a large piece of civil engineering to do to prepare the site, we are not going onto green field site. We're actually discriminated even worse against projects which are better, more environmentally friendly like we are, because we are actually recycling an old site to be used. Whereas, if we would have known we would have only had a year, we wouldn't have done that, we would have gone on a green field site. (BIOM- Applicant)

4.41 This CMO encompassed a wide variety of feedstocks, including some cases which were fully or partly reliant on food waste. The difference between these cases and those fitting CMO1a was the security of supply. Unlike those fitting CMO1a these cases had some security of supply through being linked to food waste collection businesses. In one example, the parent company of the developer had established a food waste collection business. In another, the plant was co-located with a food waste collection business.

One of the main attractions of [plant name] is there's an existing food waste treatment plant there, which was part of the scheme. There's an existing business receiving, trading and processing food waste, which is what will be used in the AD project. That's a real plus, basically. (BIOM- Applicant)

4.42 Some of the packaged food waste, which required pre-treatment, attracted a gate fee, although this was reported to cover the costs of de-packaging rather than being an income stream as such.

The advantage of a facility such as this is because it is taking food waste. There is some revenue available from the waste, but unlike… I've seen WRAP studies, going back a number of years, where it talked about £30, £40, £50 a tonne. Frankly, that is pie in the sky. The gate fees that you get just about cover the cost of operating the depackaging and the time and effort that… You have to pay a man to physically sit and process that material through a depackager. You then have to pay for the 5% to 10% residual inorganic material, the packaging material has to be disposed of. (BIOM- Applicant)

4.43 It was apparent that gate fees were insecure, however, and could not be relied upon in the longer term.

The way that my funders are structuring this is that they are assuming gate fees for the first two to three years of operation at a discounted level from what we think they're going to be at. Thereafter, there is an assumption that gate fees don't exist. (BIOM- Applicant)

Gate fees are falling all the time. With the high digestate price, the economics of this site are pretty slim for the risk someone's going to take to build it. (BIOM- Applicant)

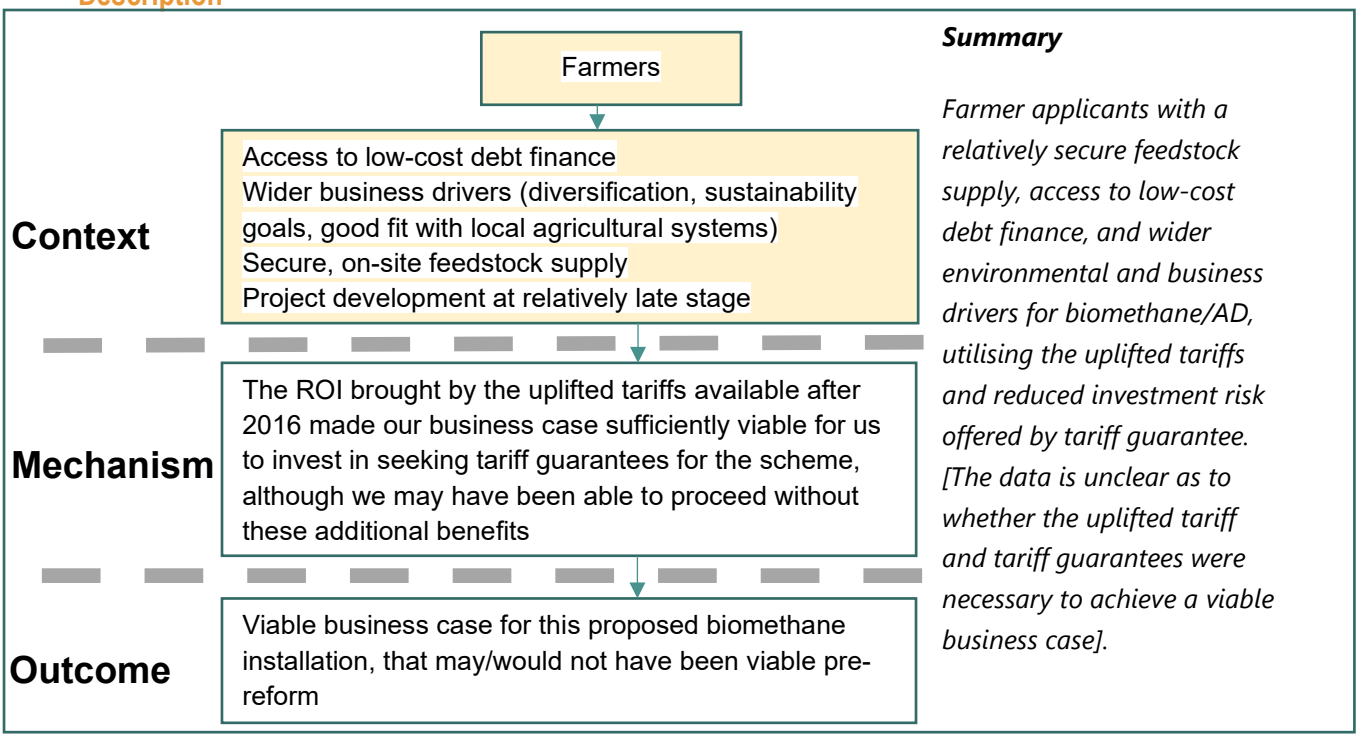
4.44 Sustainability drivers for the feedstock suppliers were important contexts in some of the cases which fitted this CMO. One applicant was developing a plant which was generating benefits for a manufacturing facility in terms of waste recycling and green gas certificates to offset gas use at the plant. Other applicants referred to wider sustainability drivers associated with the diversion of food waste from landfill.

In terms of the diversification, and what else drives the business case… Clearly, for the local authorities and the feedstock suppliers… Clearly, environmentally, it is far, far, far, more sustainable to divert the food waste into anaerobic digestion and utilise that gas, that by-product, rather than it going- If it goes into landfill, going into the atmosphere as a greenhouse gas. (BIOM- Applicant)

4.45 None of these applicants reported being able to generate income from digestate sales but the costs of disposal varied. Some farm-based schemes were reportedly able to dispose of the digestate at the host farm at low cost, whilst others were paying contractors to collect and dispose of it elsewhere. One applicant referred to quoted costs of £5-7 per tonne for their digestate disposal.

CMO1e – Environmentally-driven farmers

Description



4.46 In this CMO, the applicants were farmers, with a secure feedstock supply from their farm, access to low-cost debt finance (borrowed against wider business assets rather than the project itself) and wider environmental and business drivers for pursuing the scheme.

4.47 Although the applicants were utilising the uplifted tariff and had secured a tariff guarantee, the data is unclear as to the extent to which these were essential to the business case. One applicant reported that, under the 15% degression in January 19, the business case would still have been viable, but it is not clear if it would have been viable under the late 2016 tariffs, prior to the reform announcements, which were another 4% lower. Their current financial model shows an Internal Rate of Return (IRR) of 15.6%.

4.48 Tariff guarantees were clearly very important, but it is unclear whether they were essential.

It wasn't a big consideration because we never considered any other options. The benefits of us being able to lock it in gave us the security that we needed for the capex risk that we're taking. If it hadn't been available, we could have deemed it too risky for us. (BIOM- Applicant)

Discussion of key contexts observed

4.49 A key context was the access to low-cost finance for the scheme, with the money borrowed from a traditional lender against wider farm assets. It was recognised that this put them in an advantageous position and one applicant was able to provide a direct comparison between the costs of their finance and the costs of a specialist renewables financier.

We had a much easier ride than the majority of projects will because we've got… We've ended up going with one of our private banking relationships. I can speak on that, because we were well down the road of going a more traditional route or a more typical route. It still stacked up. The bank that we were talking to, their rates were half of what another bank had offered us and what I know other projects have.

[Specialist financier company name], who fund- they're quite active in the industry at the moment. They offered us a 13% interest with 5% fees, so it worked out as an 18% interest rate. That was getting to the limits of it not really being viable. It still was viable, but the margin is getting quite tight. You're like, "This is a lot of effort, is it worth it?" Then [bank name] ended up being just below 9% all in, which is obviously a world of difference… Where we've ended up is one of our long-term banking relationships. That is 6%. (BIOM- Applicant)

4.50 A further key context was a secure feedstock supply, with a mix of crops and farm waste sourced from the farm itself and the plant being sized based on the availability of this feedstock.

4.51 This productive use of farm wastes and the associated environmental benefits, particularly the reduction in methane emissions but also the reduction in chemical fertiliser usage was a further driver, with some applicants having a strong pro-environmental stance.

Being able to better use the farm waste products to reduce their methane contribution to the atmosphere is one factor. We'll be able to slightly reduce our diesel usage on the farm, drying grain, drying hops. There are small savings and environmental benefits there. Digestate to replace chemical fertiliser was another- All of these things are all part of the wider holistic decision. (BIOM- Applicant)

4.52 It was recognised that similar such benefits could have been achieved through the development of a biogas CHP scheme, but the decision to proceed with biomethane instead was based on this being attractive in financial terms.

I suppose, yes, if the FIT was higher, to make [a biogas scheme viable]… Do you know what, that's probably what the original decision for biomethane rather than electricity was, the economics of it. If the FIT had been high enough to balance it then yes. It still has all the same benefits to the wider farm (BIOM-Applicant).

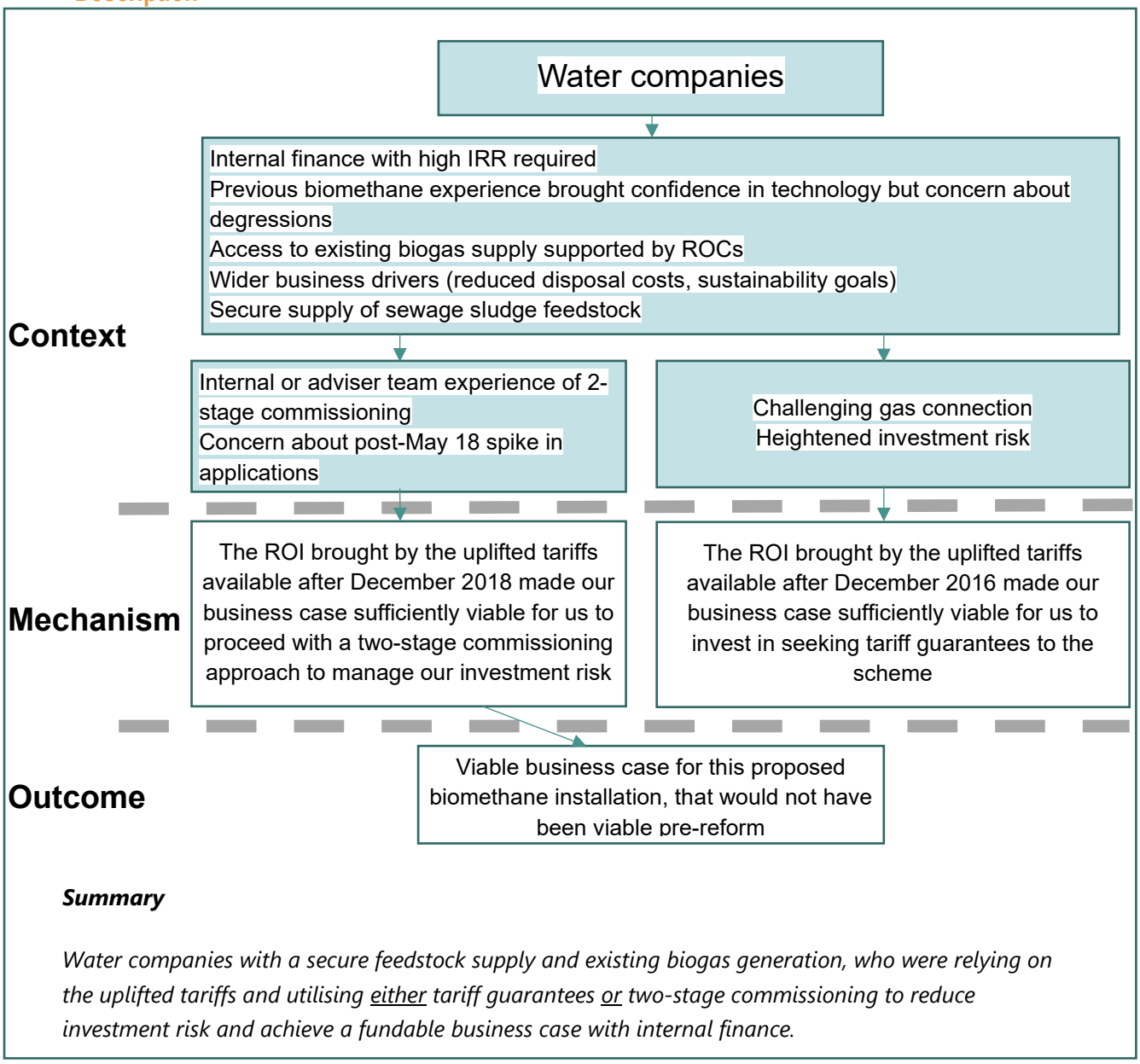
4.53 The ability to derive greater financial benefit, on top of the environmental benefits, from existing waste materials and low-value break crops was a further driver. For one applicant, this was described as the main driver.

The main driver being, at the moment, we have a dairy herd and beef cattle. We have their waste product which… ultimately you just spread onto fields to get rid of. They don't have the best nutritional value. Being able to use them, which are true waste products, and being able to get value out of them was one big thing. Then, break crops, being able to… At the moment, break crops have very limited value. We, and I think it's fair to say a lot of farmers, put them in just to benefit the ground for our wheat… At best you're breaking even, often you're actually losing

money off that crop itself but making the money back on the reduced chemicals and the benefit to the land for your wheat that comes on next. Whereas AD plants actually make maize and other break crops a viable crop in itself. It stands alone and had financial value to the wider estate, as well as all the crop rotation and soil and pest benefits that it always had. (BIOM- Applicant)

CMO1f – Water companies with existing biogas supply

Description



Summary

Water companies with a secure feedstock supply and existing biogas generation, who were relying on the uplifted tariffs and utilising either tariff guarantees or two-stage commissioning to reduce investment risk and achieve a fundable business case with internal finance.

4.54 Technically, this is two CMOs. The applicants were utility companies who were already generating biogas from sewage sludge and were adding biomethane plant to these existing operations. In spite of this secure feedstock supply, proven biogas generation and access to internal finance, the de-risking provided either by two-stage commissioning or tariff guarantees was still necessary. Variations in the context determined which of these mechanisms was utilised, as discussed further below.

4.55 The uplifted tariffs were also critical to the business cases for these plants due to the high Internal Rates of Return (IRR) needed to secure the internal finance.

Discussion of key contexts observed

4.56 The applicants had existing AD plants and were either just adding biomethane plant or adding further AD capacity alongside the new biomethane plant. In the absence of the RHI for biomethane all applicants in this group felt they would have continued with biogas production for CHP. However, the opportunity to secure 20-year RHI income for these plants, in place of ROCs which end in 2029, was a way of maximising their return on these previous investments.

Oh yes [it is a financial decision]. It's looking at time. [AD plant name]'s ROC runs out in 2029, which seems quite a way away but… The tariff guarantee will give us another 20-year horizon. Basically it's ensuring that AD is cost-effective. (BIOM- Applicant)

4.57 Relatively high IRR appear to have been expected in these cases. For example, one applicant referred to a minimum IRR of 13%, whilst another required a payback period of five years for their investment. This means that the uplifted tariffs were critical to the business cases.

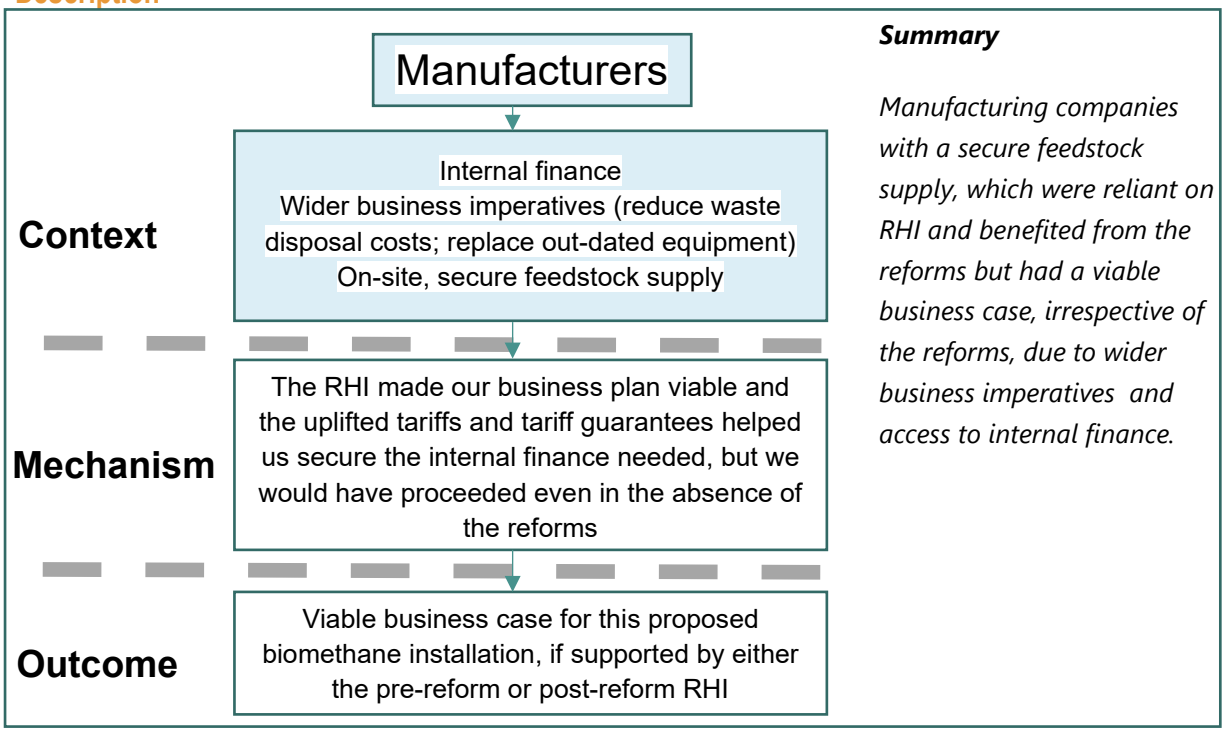
It wasn't viable until it was reset. The degression had taken the… It needed to be a higher RHI figure to entice new investment. (BIOM- Applicant)

4.58 The applicants had previous biomethane experience which gave them confidence in the technology but they needed to manage the risk of degressions by securing their tariffs early.

4.59 The diagram above indicates some of the factors which appear to have led to a two-stage commissioning approach rather than waiting for the tariff guarantees: where the applicant was using a contractor with experience of low-cost two-stage commissioning, i.e. using off-site gas for the first stage; and where the applicant was concerned about a rush of tariff guarantee applications once they became available which led to concern that this may jeopardise their access to RHI. In such contexts, the option of securing the lower tariff, knowing that this would be reset once the reforms were implemented, was deemed to be a lower risk approach than waiting for a tariff guarantee.

CMO1g – Manufacturers with wider business drivers

Description



Summary

Manufacturing companies with a secure feedstock supply, which were reliant on RHI and benefited from the reforms but had a viable business case, irrespective of the reforms, due to wider business imperatives and access to internal finance.

4.60 The applicants had a secure on-site feedstock supply from their own manufacturing facility. They benefited from the uplifted tariffs, which helped them achieve the necessary IRR to secure the internal finance needed for the project but this was not critical.

The RHI, whatever the figure was prior to the reform, yes, it went up. That made a positive difference… It wasn't critical. (BIOM- Applicant)

4.61 The tariff guarantees also helped them to secure the internal finance needed for the project.

Our lords and masters who've got the money purses, they like to see things nice and black and white and fixed. Then when you say, "We can't guarantee that because it's going to change every quarter." We obviously had to forecast that. When they were looking to reform the scheme that helped our case, if you like. Up until then you only got it from the time you first… Whatever the rate was at the point you put the first bit of gas in, was the rate secured at that point. Whereas with the new system, it secures it at the point of application. (BIOM- Applicant)

4.62 However, the wider business benefits of the scheme meant that these schemes would have proceeded even in the absence of the reforms to the RHI, i.e. they were viable under the pre-reform RHI. It should be noted that they were not viable in the absence of the RHI.

Discussion of key contexts observed

4.63 Based on limited evidence, the IRR required for these cases was lower than that required in the case of the water companies. One applicant, for example, referred to a minimum IRR of 9%.

4.64 A secure feedstock supply was available on-site, in the form of waste from the applicants' manufacturing facility. This meant that there was no issue in meeting the feedstock requirements introduced as part of the reforms.

4.65 The internal finance, secure feedstock supply and other factors relating to the general contexts will all have contributed to such schemes possibly being viable even in the absence of the reforms. However, the key context in this respect appears to have been the presence of wider business benefits and drivers. For example, one applicant described the following:

- AD produces less digestate than their existing waste treatment process, resulting in cost savings from digestate disposal
- AD/biomethane forecast to deliver 80% energy saving from their existing waste treatment process
- Their existing waste treatment process required investment to meet their increasing capacity requirements and improve its efficiency

4.66 These factors mean that in the absence of the biomethane tariff, it is likely that such applicants would have pursued AD regardless, underpinned by another subsidy.

CMO1h – Applicants adapting to the reforms

Description

Applicants whose technology choice, feedstock choice, scale or investment timing was influenced by the pre- or post-reform RHI

4.67 Having established that all of the cases in our research would not have been pursued in the absence of the RHI, in that respect this CMO applied in all cases. From the perspective of evaluating the reformed RHI, what is of most interest is the ways in which the reforms impacted on technology choice, feedstock choice, scale and investment timing. Each of these is explored in turn below.

Technology choice

4.68 We found some limited evidence of applicants' removing planned digestate drying from their schemes as a result of the reforms, although it was suggested that this did not have a significant impact on the business case for the schemes, with the cost savings in terms of digestate disposal offset by the reduced investment needed to build the drying process.

4.69 As an indication of the negligible impact of this reform on the business cases for schemes, we observed one case where digestate drying was still being incorporated (without benefiting from RHI support).

4.70 A technology supplier interviewed as part of the research indicated that the way the reforms had been implemented may have impacted on the choice of the upgrade plant technology utilised in projects. As indicated by CMO1a and CMO1c, the reforms enabled developers to access external finance and the relatively high cost of this finance meant that business cases were often reliant on re-financing or sale of the schemes once operational. Development costs

were perhaps of higher significance than operational costs in such cases, which may have led to greater use of membrane systems, which tend to be cheaper to install but have higher operational costs (due to the need for the replacing of the membrane, the costs of which, it was suggested, could amount to 40% of the original capital expenditure). The implication was the lifecycle costs may not have been optimised in all cases.

4.71 The commissioning deadline for tariff guarantee applications may also have exacerbated this situation. An upgrade plant supplier indicated that some plants may be proceeding with membrane systems because they can be installed more quickly, even though a water scrubbing system may be more appropriate, although investor concerns may also be a factor behind such decisions.

As I say the fashion at the moment is membrane, and part of that it's seen as a plug and play, it's almost seen as a shipping container, you drop down at site and you plug in. It isn't that simple, it's sold as that simple but it is a lot simpler than water wash.

Water wash, like I say, has three towers with interconnecting pipework outside of process and closure, so a typical water wash system would probably take two to three months, depending on the size and the location, to install … and membrane, you're probably talking four to eight weeks, so two months maximum. It's stripping out straightaway a month at least.

I do again, I mean, you talk to others in the industry, because of the way certain projects are financed in terms of whether it's pension fund investments or other, they see membrane as a safer solution if the project was to run into financial problems, because the belief is that the investors could come back and claim the equipment, just picking it up and sticking it on a truck as opposed to installing and grouting in a complete system. (BIOM_Upgrade plant supplier)

4.72 It was suggested that water scrubbing systems would typically be more cost-effective for larger installations over the lifetime of the plant, so the use of membrane systems in such cases may undermine profitability and/or viability in the medium to long-term.

Feedstock choice

4.73 As noted in relation to the previous CMOs, some plants were planned on the basis of utilising feedstocks which met the feedstock rules which were introduced. It was also suggested that the cost of crop feedstocks meant that applicants were increasingly using waste-based feedstocks as a result of tariff degressions anyway, meaning that the new rules were simply a further 'nudge' in that direction.

We had to, let's say, search a little bit harder for alternative feedstocks to crops. But, we normally do it anyway, because crops are quite expensive to process, and to source. Yes, we sort of in a way had started to do it before these limits were being introduced… I would say that the degressed tariffs had a big impact on this, rather than the rules. (BIOM- Applicant)

4.74 As noted in paragraph 3.5, it was suggested that some schemes were abandoned because of the developer's inability to meet the new feedstock requirements and access the uplifted tariffs.

Scale

4.75 We did not find evidence in the qualitative fieldwork of applicants adjusting the scale of their plants as a result of the reforms to the RHI. Some applicants referred to the impact of the tiering of tariff rates, which it was suggested had led to plants being sized in relation to the tiers (particularly the tier 1 limit of 40,000 MWh). However, tiering was introduced in January 2015, rather than as part of the package of reforms announced in December 2016. We will be able to carry out further analysis of the potential impact of the reforms on scale during the synthesis process.

Investment timing

4.76 In all but one of the observed CMOs applicants were reliant on the uplifted tariffs and/or the tariff guarantees to achieve viable business cases for their projects. The introduction of these reforms therefore had a significant effect on the timing of applications to the RHI. This can be explored further in the synthesis work but application data indicates:

- a hiatus in applications following degressions in 2016;
- an increase in applications following the reform announcements in December 2016, which gave new applicants access to the uplifted tariffs once implemented, providing that feedstock requirements could be met;
- an increase in applications prior to the implementation of the reforms due to (a) concerns about the availability of tariff guarantees leading to the available RHI resource being exhausted and the scheme suspended and (b) the supply chain for delivery of schemes being put under too much pressure after that point;

Interviewer: Were you racing to be near the start of the queue?

Applicant: Yes, massively. Even now- We're not in the industry really, other than the contacts we've made since this project. Everyone we've spoken to, consulted on it, has told us, "It's going to be a race, everyone is going to be there. There is limited capacity, it's all going to be gone in the first day or two." It was very much a pressure, 22nd May, you've got to be there and you've got to be ready. (BIOM- Applicant)

We knew that there were a number, let's say 20 or 30 people, 30 companies, that were likely to apply, and it was a finite budget or a finite pot. So we knew it would just be a mad rush. Once the regulation changed there would be a mad rush for people to try and obtain the reset tariff…As it was a finite pot the concern was you might not get in in the first tranche. Therefore, it could delay your development. Or you could actually not obtain the reset tariff, and there might be a degression before you get the tariff assigned to you, which means that your paybacks would be reduced, etc. It's all about getting the maximum reset tariff available. (BIOM- Applicant)

- a spike in applications following the implementation of the reforms May 2018 when tariff guarantees became available; and
- a major decline in the level of applications after May 2018, as applicants wanting to secure a tariff guarantee had to be able to commission their plants by 2020.

5 Other findings

Summary of other findings relevant to future policy

5.1 This section summarises other findings that are relevant to future RHI policy on biomethane. These are presented in Table 5.1 below, against the contexts required for viable biomethane investments.

Table 5.1: General context for viability of biomethane investments

Requirements of viable biomethane business cases	Summary of findings from this research
Access to financially viable gas injection point	This was reported to be a critical part of any biomethane business case. Proximity to a medium, intermediate or high-pressure gas main was critical to the business case for all the biomethane investors interviewed. The only exception were plants using standalone injection points. High-pressure connections were reported to be advantageous in terms of capacity and gas off-take but involved higher capital costs. Lack of grid capacity in the local gas network was reported to be a constraint on a significant proportion of candidate projects, except in the South East of England where gas demand was higher. Capacity issues were linked to local gas demand and were more of a constraint in summer than winter. Capacity issues were reported to be less of an issue for high pressure pipelines serving a wider market. The process of getting gas injection approved by both Ofgem and the local gas network operator was reported to be highly bureaucratic, with the tariff guarantee process requiring more evidence than previously required under the pre-reform RHI.
Access to land	In most cases, land for biomethane plants was leased from an independent landowner or farmer. The research found examples of landowners developing plants on their own land: with the exception of one farmer, these were water companies and industrial companies. Locational factors included: • a site on which planning permission would realistically be granted; • for food waste collectors, proximity to urban areas which generated food waste; • more generally, proximity to feedstock sources; • sufficient closeness to the countryside, including arable land, for easy distribution of digestate; • well-developed infrastructure, including nearby gas pipelines; • a level site with good ground conditions; and • for plants near London, reasonable rents/lease fees.
Planning permission and relevant environmental permits secured	Rural sites away from population centres were reported to be more likely to obtain planning permission for a biomethane plants, but the drawback of such sites was that they might not have access to a suitable gas pipeline. Consideration had to be given to the number of truck movements that would be acceptable from a planning viewpoint, which could limit use of waste feedstocks on a farm-based plant. Permits were required from the Environment Agency (EA) for some categories of feedstock.
Cost-effective access to	Confidence in biomethane upgrade and injection technology was a pre-requisite for investment. The suppliers of AD and biomethane technology were reported to be mainly

Requirements of viable biomethane business cases	Summary of findings from this research
appropriate technology	European (e.g. from Germany or the Netherlands). While there was evidence of UK companies supplying grid entry units, there was no evidence of UK companies supplying AD plants or biomethane upgrade units. The capital cost of the biomethane plant and associated equipment was reported to have a significant impact on the business case. Different providers were reported to have a price difference of 10% to 15% in terms of capital costs, with the cheaper providers being seen as lower quality. Operating and maintenance costs were reported to be significant, particularly for large plants where they could exceed £1million per year. Operating costs were reported to be lower for water wash systems than membrane or desiccant systems, because the latter need to be replaced after three to five years, at significant cost.
Access to appropriate electrical supply	Biomethane plants do not require major connections for the export of electricity, unlike major CHP plants powered by biogas. Biomethane plants often generate power from a small CHP plant onsite (around 500 kW). Biomethane tariffs were reported to have opened up potential for AD in some locations where electrical grid access or capacity is constrained.
Access to cost-effective internal or external finance	Companies that had significant funds from their broader businesses, such as water companies and major industrial companies, made use of internal finance sources. Internal finance tended to be cheaper and less demanding in terms of approval processes than external finance, although hurdle rates of return as high as 9% were reported. External loans that were secured against land or property assets were reported to be cheaper and less problematic than project finance. Farm-based developers had more scope to access asset-backed loans because of their significant landholdings. Biomethane developers without access to internal finance or secured loans had to access external project-based finance via 'Special Purpose Vehicles' (SPV). Funders were reported to look for high returns (typically 17-18%) to compensate for the higher level of risk involved in project finance, including: • Regulatory risk (e.g. getting approval for gas injection) • Construction risk (particularly related to commissioning ahead of the tariff guarantee deadline) • Operating risk (e.g. failure in sensitive AD processes) • Feedstock risks (e.g. quality, security of supply, price) Developers reported that they had to invest significant funds themselves up front to get their projects well enough developed to obtain project finance. This was typically several hundred thousand pounds. Developers mentioned that refinancing of SPVs was often planned, once the project was commissioned and construction/commissioning risks no longer applied.
Cost-effective access to feedstock supply which meets post-reform requirements	Securing supplies of feedstock that met the 50% waste requirement at reasonable cost was a critical factor in determining the viability of the business case for the AD/biomethane developments that we studied. Investors wanted to see a long-term contract for feedstock supply, to de-risk or fix this element of the business case. Where possible AD/biomethane plants were reported to be constructed close to potential feedstock supplies, to minimise the transport of bulky feedstock.

Requirements of viable biomethane business cases	Summary of findings from this research
	Some plants were reported to use up to 50% energy crops, at considerable cost. Prices for energy crops were reported to be volatile, depending on weather in a particular growing season. While energy crops provided good gas yields, developers tried to boost their gas yields using other feedstocks that were lower cost or that provided income from gate fees. Gate fees were reported to be available for some types of waste, particularly food waste that required depackaging and pasteurisation to meet the PAS110 quality standard for digestate. Gate fee income was important to cover the additional costs of pasteurisation and depackaging. Gate fees for food waste were reported to have fallen from £30-50/tonne a few years ago to £20/tonne or less. In areas with substantial AD capacity (e.g. London, NW, Midlands), competition for food waste streams was reported to be driving gate fees very low or close to zero. There were other instances of business cases involving avoided waste disposal costs that were internal to an organisation and did not involve the payment of gate fees (e.g. for sewage waste and industrial waste).
Cost-effective outlet for digestate	Digestate was not reported to be a significant source of income in the business case for AD/biomethane plants. Instead, digestate disposal was reported to be a cost for most plants. This depended on the nature of feedstocks, the quality of the digestate, the proximity of farmland to the plant and the availability of alternative organic fertilisers in the local area. Applications made after 22 May 2018 do not include use of biogas for digestate drying as an eligible heat use, as this was disallowed by the reforms.
Non-RHI revenue streams	Respondents mentioned three main groups of non-RHI revenue streams, all of which had disadvantages relative to RHI (particularly first tier RHI). There were: • gas sales – formed a significant element of business case (typically 20-30% of income but fluctuating); • existing incentive schemes such as ROCs and FiTs – now much reduced or closed to new entrants so biomethane RHI was seen as an alternative to these incentives; and • emerging but currently uncertain revenue from other sources (including CO_2 sales and new incentive schemes such as Green Gas Certificates and Renewable Transport Fuel Certificates (RTFCs)). Investors in large biomethane installations reported that they had negotiated with Ofgem to allow RTFCs to be used as the source of subsidy for production of biomethane above 40 GWh per year (i.e. the threshold for tier 2 tariffs), because RHI rates above this threshold were less attractive than predicted RTFC rates.

More detailed findings on general contexts for demand theory

5.2 This section presents more detailed findings on other general contexts that were observed for the biomethane respondents. These were observed to some degree by all respondents but were either essential pre-requisites for the business case to be viable (e.g. planning permission secured) or contexts that formed a less significant part of the business case than the key contexts outlined above.

Table 5.2: General context for viability of biomethane investments

General contexts for viable biomethane business cases	Relationship to business case
Access to financially viable injection point (a function of distance, pipeline pressure, capacity, approval speed)	Pre-requisite for business case
Access to land (typically leased in the case of developer applications & owned in the case of others)	Pre-requisite for business case
Planning permission and relevant environmental permits secured	Pre-requisite for business case
Cost-effective access to appropriate technology	Pre-requisite for business case
Access to appropriate electrical supply (from grid and/or associated CHP)	Pre-requisite for business case
Access to cost-effective internal or external finance	Pre-requisite for business case
Cost-effective access to feedstock supply which meets post-reform requirements	Pre-requisite for business case - compliance with 50% waste requirement essential for post-reform business cases
Cost-effective outlet for digestate (income from digestate sales is rare and never a significant income stream)	Part of business case - less significant than key contexts
For applications after 22 May 2018, a business case which was not reliant on digestate drying (note that this does not mean that no digestate drying is incorporated in plants)	Pre-requisite for post-reform business cases
Non-RHI revenue streams low, with only gas sales income forming a significant element of business case (typically 20-30% of income but fluctuating)	Part of business case - less significant than key contexts

5.3 Evidence about these general contexts, and their role in business cases for biomethane installations, are set out in more detail below.

Gas network connections

5.4 Connection to the gas grid was reported to be a critical part of biomethane projects. Those projects with more complex connections were regarded as more risky and therefore more dependent on TGs to facilitate investment.

Because of the complexity of [project name], with its pipeline, we couldn't run the risk at that time [i.e. before TGs]. The critical path is the gas pipeline. We've spent an awful lot of time with [the

gas network operator], the land owners, etc. trying to smooth the way, even though it's not our responsibility to help facilitate, using our contacts, etc. (BIOM-Applicant)

5.5 Securing a viable connection was also reported to a barrier to future development of biomethane.

5.6 In the rest of this sub-section, we present evidence about the influence of contexts relating to the proximity of gas network connections, the pressure of the pipe to which the connection is made, the availability of capacity in the gas network, the approval process for gas connections and evidence relating to standalone connection points.

Proximity

5.7 Proximity to a medium, intermediate or high-pressure gas main was critical to the business case for all the biomethane investors interviewed. This was a screening criterion for most biomethane investments, because of the high cost of constructing a pipeline from the biomethane upgrade plant to a grid entry unit on the gas grid. The only exceptions were plants using standalone injection points (as discussed separately below).

5.8 Respondents reported that their plants required pipelines varying from a few hundred meters up to 2km. An exception was a plant requiring a 4km pipeline, which remained viable because part of the pipeline was built over land owned by the client and because this biomethane investment would use gas from an existing AD plant.

5.9 Shorter pipelines were quicker and cheaper to construct, particularly if the pipeline could be constructed on land belonging to one of the project partners.

So we've got a connection already, but there's an intermediate pressure gas main almost running adjacent to the site. [..] As it's so adjacent, that influenced some of the costs. It's running along our fence line almost. (BIOM-Applicant)

5.10 Quicker construction was critical for those plants that had TGs and needed to commission their plants by January 2020.

Well, it doesn't make a huge difference in terms of the capital cost, but it was an advantage when we were looking at things that we might be able to do quickly. (BIOM-Applicant)

Pressure

5.11 Connecting with a high-pressure pipeline was reported to be advantageous in terms of capacity and off-take of gas (see below), but capital costs were reported to be higher for high pressure connections. For example, for pressures above 7 bar, it was reported that pipes had to be steel rather than plastic, which pushed up capital costs.

I think it was around about 30bar that we were going to go into. [But] it was the capital cost of the pipeline that started to affect the viability of the project. (BIOM-Applicant)

5.12 Connection to transmission pipes or high-pressure pipes was also reported to be more time-consuming than connection to medium- or intermediate-pressure pipes, because of higher gas safety risks and more extensive safety assurance requirements.

5.13 The extra time required to connect to high-pressure pipes was particularly problematic for plants with TGs because of the requirement to commission their plants by January 2020.

Then we have a high-pressure pipe, about a kilometre away, across our land which we were going to connect onto. We had to change because of the RHI deadline, they didn't think they'd get us connected in time. We've actually ended up with a medium-pressure pipe in the village, that is two kilometres away. (BIOM-Applicant)

Capacity

5.14 Assessing the capacity likely to be available in the grid is part of the investment case for a biomethane project.

5.15 Lack of grid capacity in the local gas network was reported to rule out a significant proportion of potential biomethane projects.

In 50% of the time, we try to do a project. So, where there might be a good feedstock, or waste feedstock, the grid just doesn't have the capacity. (BIOM-AD Operator)

5.16 A gas network operator reported that – based on customer feedback - flow rates of 500 to 600 standard cubic metres per hour were generally needed to make a biomethane investment financially viable. But they cannot always guarantee a continuous flow of 600 cubic metres per hour, since gas demand is variable and seasonal. This gas network operator sometimes agrees to take a variable flow (higher in winter than summer) that averages out at the level required for a viable project.

5.17 Capacity in medium- and intermediate-pressure gas pipelines (and hence the ability to export gas) was reported to be linked to local gas demand. But this was perceived to be less of an issue for high-pressure pipelines that served a wider market.

5.18 However, the high population density in the South East was reported to mean that gas demand was higher and therefore capacity was more widely available in the region.

Approval process

5.19 The process of getting gas injection approved by both Ofgem and the local gas network operator was reported to be highly bureaucratic. The TG process was reported to require more evidence than previously required (e.g. not just an invoice for a network connection agreement but a receipt for the invoice from the gas network operator).

5.20 Completion of the gas pipeline and approval of gas injection were on the critical path for many plants, particularly those that needed to commission by January 2020 to satisfy TG requirements.

5.21 The complexity of the approval process was reported to be exacerbated by different policies and practices between different gas DNOs, which complicated delivery and increased costs.

The grid companies, they don't make it terribly easy. They all have different policies, and different standards of engineering, and different ownership models; and it is a bit unfortunate that they've all got their own way of doing stuff. It's very annoying for the biomethane industry that we have a lot of extra costs because they all do things differently. (BIOM-Gas shipper)

5.22 In contrast, much simpler rules and processes were reported to be applied in other countries, such as the Netherlands.

5.23 Nevertheless, there was some praise for the flexibility of some gas network operators in working with applicants to support them to meet their TG-related timelines.

5.24 For one gas network operator, the stages involved in getting approval for gas injection were reported to be as follows:

- A potential biomethane developer enquires about gas export from a particular site
- The gas network operator undertakes a 'detailed network analysis' study, funded by the developer
- If the developer decides to proceed, the gas network operator provides a 'connection offer', normally valid for a few months
- At an early stage of the project, the developer and partners undertake a GQ/8 (gas quality risk assessment)
- A 'connection offer' is issued, to support the plant's application for TG stage one. This offer involves some upfront payment and is dependent on planning permission being obtained.
- Plans proceed to construct an export pipeline, linking a 'remote operable valve' (ROV) and remote telemetry unit to the main gas network. (Pipelines below 7 bar are generally built by the developer or their contractors, to standards set by the gas network operator. Pipelines above 7 bar are usually built by the gas network operator (except for one gas network operator that was reported to have instituted a 'self-lay' protocol to expedite high pressure connections whilst maintaining safety).
- Once operational, the connection offer is replaced by a 'Network Entry Agreement' that covers the lifetime of the plant (e.g. 20 years).
- At this point, the equipment associated with the grid entry point is generally taken over and operated by the gas network operator.
- Within the NEA, the gas network operator usually has discretion to change entry requirements, including the calorific value required for the gas.

5.25 Various teams were reported to be involved in this process within a gas network operator, including a project manager (first point of contact for the customer), a technical team (checking both mechanical and gas quality aspects), an operational team (making sure that competent people are involved when gas initially flows to the grid), the system control room and the land services team (for pipeline leases and easements).

Standalone injection points

5.26 One gas network operator has a large-scale network entry facility that accepts biomethane delivery by truck from remote biomethane plants. This entry facility has a 'network entry agreement' with the relevant part of the gas network's own organisation. Capacity within this agreement is effectively sub-let to others who invest in biomethane plants which are too far from the nearest feasible gas connection. At its maximum capacity, this facility could accept 6,000 cubic metres per hour of unpropanised biomethane, equivalent to more than 12 plants within tier 1 of the RHI (i.e. below 40 GWh).

It gives the opportunity for those feedstocks to be gathered, harvested, and effectively [the biomethane] bottled, because that's what it is, the virtual pipeline. Put it into trailers of bottles, in one form or another, and move it to a point where it can be decanted and use to de-carbonise the gas grid. (Injection plant owner)

5.27 There is an additional carbon footprint from the trucking of gas but, to compensate for this, there is no need for propanation because this is a high flow station where biomethane can be blended with natural gas to achieve the correct calorific value for injection to the gas grid.

5.28 The biomethane plants using this facility do have RHI approval, but it was suggested that approval for plants using this model might be more difficult to obtain under the reformed RHI scheme. This appeared to be because of 'chicken and egg' situations relating to planning permission.

Other pre-requisites for a viable business case

5.29 We identified a number of other factors that were pre-requisites for a viable business case, including a suitable site, planning permission and (where required) environmental permits and cost-effective access to suitable technology and access to finance (internal or external).

Siting

5.30 Developers generally had to locate suitable land for the proposed biomethane plants: we interviewed one farmer/landowner who owned the site and the farm-based biomethane plant on that site. Water companies and industrial companies provided some further examples of the landowner also being the developer. But, in the remaining cases, land was leased from an independent landowner or farmer.

5.31 For biomethane developers, finding an interested landowner was listed as the third most important aspect after (1) making sure that planning consent would be granted and (2) making sure that biomethane could be exported to the grid. The landowner provided the site (usually via a lease) and could potentially supply some or all of the feedstock and also remove digestate from the plant.

5.32 Rent and lease fees were not reported to be a particularly significant cost, except in London where land prices were higher.

Compared to the costs that we've talked about there, absolutely not [significant]. Feedstock, digestate, labour, RNM bills, those are significantly- Consumable costs. Those are all significantly higher than the rent, annual rent. (BIOM-Applicant)

5.33 Further factors that were mentioned as affecting preferred sites or locations were:

- for food waste collectors, proximity to urban areas which generated food waste;
- more generally, proximity to feedstock sources;
- sufficient closeness to the countryside, including arable land, for easy distribution of digestate;
- well-developed infrastructure, including nearby gas pipelines; and
- a level site with good ground conditions.

Planning and permitting

5.34 Developers commented that selecting a site that was likely to obtain planning consent was critical. Rural sites away from population centres were more likely to obtain planning permission for a biomethane plants, but the drawback of such sites was that they might not have access to a suitable gas pipeline.

5.35 In assessing whether a particular site was likely to obtain planning permission for an AD/biomethane plant, consideration had to be given to the number of truck movements that would be acceptable from a planning viewpoint. This could limit the use of waste feedstocks on a farm-based plant.

5.36 Permits were required from the Environment Agency for some categories of feedstock.

Cost effective access to appropriate technology

5.37 Confidence in biomethane upgrade and injection technology was a pre-requisite for investment. Respondents acquired this confidence either through their own experience (e.g. prior involvement with other AD and biomethane plants) or by employing an experienced technical adviser.

5.38 Developers reported experience and confidence with biomethane technology. There were reports of a developer placing an order for several biomethane upgrade units and reported actively looking for opportunities to deploy them.

The technology providers, we have a fair bit of experience now. We have a fairly small group of people we tend to work with. To some extent, a lot of this equipment turns up in a container, so it can be put more or less anywhere. (BIOM-Applicant)

5.39 While most developers put forward AD plants in tandem with biomethane proposals, a few developers specialised in biomethane upgrade to complement AD investments by others. The choice of upgrade technology (membrane versus water wash) was also reported to depend on past experience (i.e. choices being based on the processes developers were more familiar with).

5.40 The suppliers of AD and biomethane technology were reported to be mainly European (e.g. from Germany or the Netherlands). Experienced European suppliers were reported to have

good knowledge of the UK market and regulations, as well as the technology. One supplier was reported to have delivered 500 AD plants in the UK, including several large-scale food waste plants, while another had delivered 50 in Europe. While there was evidence of UK companies supplying grid entry units, there was no evidence of UK companies supplying AD plants or biomethane upgrade units.

A lot of the equipment that gets deployed in the UK comes from Europe … Northern Europeans have been doing biogas for decades. The engines come from Europe, almost exclusively. There are a couple of British [firms], but they're not brilliant. (BIOM-AD operator)

5.41 The capital cost of the biomethane plant and associated equipment was reported to have a significant impact on the business case.

Probably the second biggest factor after the RHI tariff is how much capex is it going to cost? (BIOM-Applicant)

5.42 Different providers were reported to have a price difference of 10% to 15% in terms of capital costs, with the cheaper providers being seen as lower quality.

Well, yes, sometimes actually when you compromise with 10%, 15% of the price, you get 20% to 25% to 30% impact on the quality. There could be a significant difference in disproportion between the two. (BIOM-Applicant)

5.43 Biomethane investments are typically multi-million pound projects, with the grid entry unit comprising a significant part of these costs. An estimated 50% of this capital cost was reported to be used for civil works, with the remaining 50% being for equipment. Respondents reported that there was less scope for cost reduction over time than in some other renewable energy industries (e.g. wind) because of the high proportion of civil engineering costs.

5.44 Operating and maintenance costs were reported to be significant, particularly for large plants where they could exceed £1million per year.

To actually provide operational maintenance support, just to physically operate it and maintain it is about £800,000. We then have a further £350,000 of ancillary costs to the project, for management, for rent, for your rates, insurances, accounting. There is another £350,000. [..] Over and above all of that, there are then the funder's costs. (BIOM-Applicant)

5.45 Operating costs were reported to be lower for water wash systems than membrane or desiccant systems, because the latter need to be replaced after three to five years, at significant cost (possibly as high as £1 million for a new membrane).

5.46 Other elements of running costs were reported to be the cost of feedstock (see sub-section below), the cost of propane (to raise the calorific value of the biomethane to match natural gas) and the cost of buying natural gas to heat the AD digesters.

Access to an electricity supply

5.47 Plants required some form of electricity supply to run their plants. This could be either a grid connection (typically at least 500kW capacity) or could be generated from biogas using a small (typically 500 kW) onsite CHP engine.

5.48 Biomethane plants do not require major connections for export of electricity, unlike major CHP plants powered by biogas, meaning that biomethane tariffs have opened up potential for AD in locations where electrical grid access or capacity is constrained. In one case in our sample, biomethane investment was enabling expansion of an existing AD plant that was already exporting electricity but was constrained from undertaking further investment in biogas CHP because of the size of its grid connection.

Access to finance

5.49 This sub-section provides general insights into financing considerations, which formed a major part of the business case for biomethane because of the high capital costs involved. This sub-section supplements specific evidence on the relationship between TGs and financial approval set out in the descriptions of CMOs in section 4.

Internal and asset-based finance

5.50 Those companies that had significant funds from their broader businesses, such as water companies and major industrial companies, made use of finance sources internal to their organisations. Internal finance tended to be cheaper and less demanding in terms of approval processes, although hurdle rates of return as high as 9% were reported for internal finance.

5.51 Loans that were secured against land or property assets were reported to be cheaper and less problematic than project finance. Farm-based developers had more scope to access asset-backed loans because of their significant landholdings.

We, by securing a loan against the value of our own land, will enjoy a much lower interest rate than if you had to go for a loan which was taken against the plant. [..] we'd be talking a much lower interest rate – maybe about 4%. (BIOM-Applicant)

5.52 However, only those farmers or landowners with experience and confidence in running large-scale capital projects could contemplate developing a multi-million pound AD/biomethane plant themselves. For most farmers, the capital investment required for these projects were simply too large and risky for them to take out loans on their own business.

External project-based finance

5.53 Where other funding sources were not available and project finance was required, biomethane developers referred to the creation of a 'Special Purpose Vehicle' (SPV) for each biomethane project. This is a corporate structure designed to facilitate access to project finance from external funders. Finance companies were then be approached to contribute equity or loan finance to the SPV.

5.54 Since project finance is not backed by assets or securities, funders look for a higher return to compensate for the risk that they will not get their money back on some projects.

Obviously the funders, that are investing £16m into this, need to know that there is a return available. This sort of transaction, it is non-recourse project finance. This isn't substantiated by a security against £20m worth of land or assets. (BIOM-Applicant)

Risk-reward relationship

5.55 Financiers reported that AD and biomethane plants were perceived as riskier than some other renewable energy investments (such as solar farms) and therefore the IRRs sought from project finance were higher. Larger corporate equity providers (carrying significant risk but with potentially much higher returns if the project is successful) were reported to seek at least 10%. Debt providers, who would get a fixed return and might not be repaid if the project was unsuccessful, were reported to require very high IRRs (e.g. above 30%) if they were carrying risk for all aspects of project development from the start through to operation.

5.56 From the funders' point of view, the risks associated with AD and biomethane projects included regulatory risks (e.g. getting approval for pipelines, gas injection and RHI), construction risks (e.g. the need to commission ahead of the TG deadline), operating risks (e.g. the sensitive biological nature of AD processes, which ramp up slowly over weeks/months; and the risk of bacterial processes failing owing to feedstock quality issues, requiring 'wash out' and repetition of the ramp up process) and feedstock risks (including feedstock security, quality and price). These risks were reported to make AD/biomethane investments riskier than (say) solar farm investments, so funders looked for higher returns.

In a solar project, ground mounted solar, investors are looking for the generative project level returns of circa 6%. AD projects, the project level returns are circa 11% on a project IRR basis. (BIOM-Financier)

5.57 Typical IRRs for project finance were reported to be in the range 10-17%. While the minimum return sought might be between 10-13%, evidence suggests that funders looked for risk margins to cover unforeseen issues (including uncertainties about the timing of Ofgem approvals) and also charged fees above this. So the final IRR required was typically higher, around 17-18%.

So the initial construction finance is at 13% interest. So we've got to be able to do better than that and we've got to have digression sensitivity analysis and all sorts of things. So we're going to be looking at a 17% ROI to satisfy the funder. (BIOM-Applicant)

5.58 AD plants using food waste feedstocks had particular problems demonstrating security of feedstock supply, unless they were able to secure a local authority contract for food waste. This is discussed further in the feedstock section below.

5.59 There was evidence, from the small number of funding companies involved in the biomethane projects, that biomethane funding was a specialist area. Respondents reported that many funders found AD/biomethane projects too risky for the current level of returns. Those funders who had remained in the market had in-depth interest in, and understanding of, AD and biomethane projects.

I mean, before we got to [funder], we would have spoken to 15 investors, of which over 10 of them have got out of the AD market, or are only buying up operational assets. Funders just see the risk of AD as being too high. So, only the people who have a real desire to be involved are. (BIOM-Applicant)

5.60 But, at the time of this research, equity finance was reported to be particularly difficult to obtain for new AD/biomethane plants. This was because financiers were aware that construction generally took 12 months, that plants needed to be commissioned by January 2020 to obtain TG stage 3 approval and that this deadline was less than 12 months away.

Upfront costs

5.61 Developers had to invest significant funds themselves up front to get their projects well enough developed to obtain project finance. This funding was 'at risk', and would be lost if the project did not go ahead. This usually amounted to several hundred thousand pounds, and could exceed a million pounds for very large projects with high pressure connections.

It'll cost us somewhere in the region of £200,000 to get it to a point of development that allows us to take it to funding. So, that's the bit that we fund under our risk. (BIOM-AD operator)

5.62 Delays implementing the reforms and approval delays for TGs had extended the period over which these upfront costs had to be carried, without any income from biomethane. This had put some smaller companies at risk, particularly if they did not have other sources of income.

5.63 Project delays, including those arising from the RHI reforms and from TG approvals, and changes to the business case (e.g. rising feedstock costs; increased interest rates) were reported to have put some financing arrangements at risk. Delays in commissioning increased the risk of projects defaulting on loans because they could not commission and ramp up production in time.

It's taken 18 months before we've got any confidence in the project and the funders. And that 18 months added on millions of pounds to the project. [It] affects the project development costs, which all have to be put onto this how much has been borrowed. And now with the high interest rates we have to pay back, it's just putting more pressure on the project to perform. (BIOM-Applicant)

Refinancing

5.64 Developers mentioned that refinancing of SPVs was often planned, once the project was commissioned and construction/commissioning risks no longer applied. Initial investors were reported to look to invest over a relatively short time-frame (e.g. three years) until the project was operational and lower risk. However, few AD or biomethane projects were reported to have yet got to this point of refinancing because they were relatively new.

5.65 The refinancing would involve selling the future income streams, including the guaranteed 20-year income stream from RHI, in return for cheaper finance. Earlier refinancing was envisaged for lower risk projects (e.g. those with secure feedstock streams).

5.66 The high rates of return required initially, during the risky construction and commissioning phase, were reported to be needed to ensure that the project would remain financially viable (and able to service construction finance debts) until it could be refinanced.

5.67 Returns for equity investors were reported to be greater towards the end of the 20-year RHI timeframe, when a second phase of lower-interest debt finance had been paid off.

Then there are 5 years at the back end where, if all goes well, there is a potential for a return for the equity holders in the project. (BIOM-Applicant)

Financial close

5.68 Finally, respondents reported that the definition of 'financial close' in the TG process did not quite match the real process of financial close. This gave rise to an impasse on some projects, as described in section 6, where Ofgem would not give TG Stage 2 approval until financiers had committed to fund the project, but financiers would not commit to fund the project until TG Stage 2 approval gave them the assurance that the RHI tariff level would be guaranteed by the TG.

Cost effective access to feedstock supply

5.69 The nature and cost of the feedstock supply, and its compliance with the 50% waste requirement, formed an important part of the business case for AD/biomethane plants. A summary of feedstock characteristics is shown in Table 5.3 below.

Table 5.3: Feedstock contexts – by feedstock type

Feedstock type	Examples cited by respondents	Key aspects of this feedstock that influence the business case, as described in section 4
Farm waste	Slurry from dairy farms, belly grass from abattoirs, crop wastes and residues (e.g. straw, sugar beet pulp), straw, straw/manure from poultry, pig and cattle	Low or no cost. Potential gate fees for belly grass. Secure supply if feedstock is provided by landowner's farms and other local farms. Slurries and manures give lower gas yields, so need to be combined with energy crops or other higher yielding feedstocks. These waste streams are therefore lower value than food waste and are not worth transporting over long distances. The ramp-up process was reported to take longer for farm waste AD plants, creating more operational risk.
Energy crops	Maize and maize silage, rye silage, grass silage	Higher yielding but energy crops have a purchase cost. Secure supply if feedstock is provided by landowner's farms and other local farms. Requirement that energy crops had to be less than 50% to qualify for the uplifted tariff and TG (all respondents had chosen to comply with this rule).
Sewage waste	Sewage sludge, cesspit waste	Secure feedstock stream from water companies.

Feedstock type	Examples cited by respondents	Key aspects of this feedstock that influence the business case, as described in section 4
		Avoided disposal cost (so implied 'gate fee') – but usually processed by water companies themselves so no transaction cost. Plants using only sewage sludge are exempt from EA permit requirements that apply to industrial wastes.
Manufacturing/ industrial waste	Whey and whey permeate from dairy processes, wastes and residues from distilleries and breweries, food waste from food processing, effluent from paper manufacture	Potentially secure feedstock stream, particularly if co-located with industrial plant. May have value or command a gate fee depending on the type of waste. Permitting requirements vary according to whether the feedstock is classified as waste or a 'residue' or 'effluent'. EA permits are required for handling waste streams but not residues/effluents. Food waste that requires pasteurisation (to meet the PAS110 standard for digestate) is more likely to command a gate fee.
Municipal and commercial waste (typically sourced from waste collection companies, i.e. not directly from LAs or other sources)	Household food waste (no packaging). Commercial food waste (e.g. restaurants, shops, supermarkets, cafes, schools, hospitals) – can involve packaging Green waste from composting activities	Difficult to get secure feedstock stream, owing to dependence on food waste collection processes or contracts, unless co-located with food waste transfer plant. Avoided disposal costs (i.e. gate fees). Food waste that needs to be depackaged (e.g. supermarket waste) attracts more of a gate fee, but depackaging and disposing of packaging waste adds cost. PAS110 standards need to be met for food waste.

5.70 Further detail on the contexts associated with feedstocks, and their implications for CMOs, are set out below.

Security of feedstock supply

5.71 As explained in section 4, securing supplies of feedstock that met the 50% waste requirement at reasonable cost was a critical factor in determining the viability of the business case for the AD/biomethane developments that we studied. Investors wanted to see a long-term contract for feedstock supply, to de-risk or fix this element of the business case.

The board would not have sanctioned the build of the plant without having a rock-solid contract for feedstock for a 15- to 20-year term in place. So, yes, that was a critical factor. (BIOM-Applicant)

5.72 The most secure feedstock supplies were those owned by key partners in the relevant AD/biomethane development. For example, water companies could access secure supplies of sewage sludge; owners of food processing sites could access secure supplies of food residues and wastes; and landowners involved in agriculture could access secure supplies of animal wastes and crop residues. The core business case depended solely on the partner's own feedstock supplies, while similar supplies from other organisations in the local area could provide potential upside.

[Plant name] is a sewage treatment works, where we have a large digestion capability. We digest sewage sludge that's indigenous to that site. We also bring in sewage sludge from surrounding sewage treatment works into that site. So we have sort of a hub where we can do all the digestion and reduce volumes and reduce methane. (BIOM-Applicant)

5.73 One developer had improved feedstock security for their farm-based plant by choosing a location with poor soils. This meant that local farmers were likely to need to continue growing maize (which could be used as an energy crop) because they could not grow more valuable crops such as wheat, barley, peas and beans.

5.74 There was evidence that local farmers were offered deals whereby they provided feedstock free of charge, in return for use of digestate from the AD plant.

5.75 AD/biomethane plants processing food waste had the least secure feedstock supplies, except in one case where a developer was able to buy a food waste transfer site and use this as the location for an AD/biomethane plant.

5.76 Another developer was able to sub-contract for food waste within a local authority waste contract. The security of food waste supplies was critical to their business case.

5.77 Contracts for food waste supplies tended to be short-term, up to two years. This made food waste projects riskier for investors, requiring higher returns to justify investment.

5.78 Food waste contract lengths were even shorter in parts of the country where there were many local AD plants using, or planning to use, food waste. Contracts as low as three to six months were reported, because food waste providers did not want to be locked in to paying gate fees while the market was falling. There was evidence of AD developers using short contracts to attract food waste suppliers away from their competitors.

So, basically, one of the first marketing things we went out and did was just say, you know, not talking about [competitor], not talking about us, just talking about, "Don't sign long term feed stock contracts, you don't need to," which has helped. (BIOM-Applicant)

5.79 Conversely, plants in areas with few other AD food waste plants faced less competition for food waste feedstocks.

5.80 Developers in food waste AD/biomethane plants reported investing at risk, if they had the financial ability to do so, to break the deadlock in securing food waste contracts for a plant that had not yet been build.

Feedstock proximity

5.81 Where possible AD/biomethane plants were reported to be constructed close to potential feedstock supplies, to minimise the transport of bulky feedstock. This was an important consideration for location, as well as a suitable gas connection, confidence in getting planning permission and proximity to land for spreading digestate.

5.82 It was reported that transport of food waste feedstocks was easier to justify than transport of agricultural waste, because gas yields were higher from food waste.

The gas yield is such from them [farm-based wastes] that they're fairly low yielding, therefore they don't travel. With food waste, it arises and it has to travel. It has to travel somewhere. You can't spread it straight onto land, it's full of packaging, so it either has to travel to landfill or it has to travel to an incinerator or it has to travel to AD. (BIOM-Applicant)

5.83 Operators of plants using food waste reported that they chose to locate near to big urban areas to minimise transport of food waste feedstocks.

5.84 Those food waste operators that prioritised environmental considerations reported that they cooperated with other plants to minimise transport of feedstock, to reduce costs and improve efficiency.

5.85 Ofwat was reported to encourage similar arrangements between water companies that could feed sewage waste to an existing AD plant.

5.86 Where the plant was co-located with an industrial process that generated liquid effluent, then feedstock could be delivered by pipeline rather than truck.

Feedstock cost

5.87 The most costly type of feedstock was reported to be energy crops. Feedstock costs were reported to make a significant difference to the business model for farm-based biomethane.

I'm not sure whether Ofgem appreciates that plants that have to pay for feedstock, it's a significance difference to the financial model versus a plant that doesn't have any feedstock cost or even has a gate fee in certain circumstances. (BIOM-Applicant)

5.88 Respondents reported that energy crops are cheaper if ordered from farmers in advance, with a lead time for planting and harvesting at the appropriate season. Delays in biomethane plant approval were reported to cause potential problems, as energy crops might need to be bought on the open market at greater cost. Prices for rye and maize silage were reported to be between £28 to £40 per tonne, depending whether this was ordered in advance or bought after harvest.

5.89 Prices for energy crops were reported to be volatile, depending on weather in a particular growing season.

5.90 While energy crops provided good gas yields, developers tried to boost their gas yields using other feedstocks that were lower cost or that provided income from gate fees.

Gate fees

5.91 Gate fees were reported to be available for some types of waste, particularly food waste that required depackaging and pasteurisation to meet the PAS110 quality standard for digestate. Gate fee income was critically important to cover the additional costs of pasteurisation and depackaging.

5.92 Although the UK has significant volumes of food waste in municipal waste streams, this is not necessarily accessible to the AD/biomethane industry in viable locations.

We all think there's hundreds and millions of tonnes out there of food waste or waste. Yes, there is, but it's not accessible and it's not accessible in the right regions. For example, food waste, there's lots of food waste in black bag waste but we can't access that because the cost of obtaining that is too high and the [RHI] tariffs won't allow that. (BIOM-Applicant)

5.93 Respondents in areas with good feedstock supply, and relatively low competition from other AD plants, reported that gate fees were a significant source of income (although much lower than RHI and gas sales income).

5.94 Gate fees were reported to have fallen from £30-50/tonne a few years ago to £20/tonne or less. This contrasts with reported landfill disposal costs for food waste being around £120 per tonne and avoided incineration costs being around £80-100 per tonne.

5.95 In areas with substantial AD capacity (e.g. London, NW, Midlands), competition for food waste streams was reported to be driving gate fees very low or close to zero. The competition was reported to come from AD plants built to generate electricity, as well those being built for biomethane.

5.96 In other regions, it was reported that AD plants still receive modest gate fees for food waste but that business cases assume that this would decrease to zero over time.

Certainly, in initial years there is some gate fee allowed for. Obviously, we are taking waste that is otherwise sent to landfill. There is still a market, currently, for that. That dips away over the course of, probably, five to seven years. (BIOM-Applicant)

5.97 There were suggestions that annual WRAP surveys overstated gate fees because survey respondents over-inflated the gate fees they received. The volatility of gate fee income meant that funders did not count it as a core part of the business case. It was a modest contributor, covering (for example) the operational or staffing costs.

5.98 Some respondents specialising in food waste management had an integrated business model that involved food waste collection and transport as well as processing, AD and biomethane. This integrated model, which even involved use of biomethane in refuse collection trucks, potentially created efficiencies.

Other avoided waste disposal costs

5.99 There were other instances of business cases involving avoided waste disposal costs, without payment of gate fees. These instances were observed for organisations that owned a facility

producing industrial waste or sewage waste that would still require some form of treatment if not used for AD/biomethane. Cost savings in relation to aeration of liquid effluent (in aeration tanks or lagoons) was part of the business case for these investors, particularly if their aeration plant needed upgrading or expansion.

5.100 AD/biomethane was reported to require significantly less energy than aeration, and to reduce the volume of effluent spread to land. The cost savings of switching from aeration to AD formed a significant part of the business case for these investors.

The energy required on the aeration stage is massively reduced by 80%. Overall, we're forecasting around just under a megawatt of electricity saving.[..] In order of benefit, it's RHI top, gas sales second, obviously based on the current gas price. Land spreading avoidance costs would be third and energy fourth. (BIOM-Applicant)

Feedstock quality and pre-treatment

5.101 There was some suggestion that liquified, depackaged food waste (known as 'food soup') could vary in quality.

5.102 Where agricultural feedstocks or food waste was used, pre-treatment of feedstocks using pasteurisation plant was required to meet PAS 110 standards for digestate. This increased the demand for heat, often generated using biogas CHP.

Where agricultural crop is also taken into the process, we often run pasteurisation plants on those sites as a requirement for the PAS 110 and all that sort of stuff. At [plant name], because the plant is a pure, 100%, [food processing] waste and residue plant, we didn't install any pasteurisation equipment at that site. (BIOM-Applicant)

5.103 For waste streams that are harder to break down (e.g. grass, straw, sewage waste), the business case for AD/biomethane was sometimes linked to investment in a thermal hydrolysis process. Thermal hydrolysis increases the gas yield from the AD feedstock but, like pasteurisation, increase demand for heat.

5.104 In addition to pasteurisation, commercial food waste streams (e.g. food waste from supermarkets) also required depackaging. This affected the business case because of the costs of removing and disposing of the packaging. Gate fee income helped to cover these costs.

Cost-effective outlet for digestate

5.105 Digestate was not reported to be a significant source of income in the business case for AD/biomethane plants and digestate disposal was reported to be a cost for most plants. This depended on the nature of feedstocks, the quality of the digestate, the proximity of farmland to the plant and the availability of alternative organic fertilisers in the local area.

Value to farmers

5.106 Digestate was reported to have potential value to farmers. Liquid digestate is used as a fertiliser but is bulky (being typically 95% water) and can have relatively high storage and distribution costs.

5.107 Solid digestate has benefits as a soil improver as well as a fertiliser and offers benefits to farmers compared to untreated slurry and manure.

The digestate has significant benefits above slurry and farmyard manure. It's expected to replace between 65% and 80% of our petrochemical fertilisers. (BIOM-Applicant)

5.108 But some farmers are used to using fertilisers and prefer to continue doing so.

5.109 One experienced respondent reported that the acceptability of digestate as a bio-fertiliser improved over time, as farmers in a particular area got used to it.

Weak market for digestate

5.110 Currently, the market for digestate was reported to be weak, particularly in areas where there were multiple competing streams of organic material such as sewage sludge, chicken manure, pig manure, dairy manure, abattoir waste and waste from paper manufacture.

5.111 This has put downward pressure on prices. Values were reported as around £7-8/tonne. Typically 30-40 tonnes of digestate would be spread per hectare.

5.112 For AD/biomethane plants in areas with a weak market for digestate, located at a distance from farmland, digestate disposal was reported to be a cost rather than a revenue stream

5.113 Whether digestate makes a small profit or is a cost depends on the type of feedstock and proximity of the plant to farming land.

5.114 If an AD plant is located on a farm, liquid digestate can be spread directly onto fields through sub-soil irrigation networks rather than being delivered by tanker sprayed onto crops. While this requires initial capital investment, it reduces the operational costs of digestate distribution.

One of the reasons why we selected the site was because the landowner had its own irrigation system so that all the liquid digestate is pumped mechanically off the site and is spread extremely locally. It doesn't get tankered out to outlying land. (BIOM-Applicant)

Regulatory restrictions

5.115 In Nitrogen Vulnerable Zones (NVZ), liquid digestate has to be stored for spraying at the correct time of year (i.e. growing season), when it will be taken up by plants rather than running off the fields into water courses. Storage arrangements have to be approved by the EA.

5.116 EA requirements specify which forms of digestate can be used where. Source-segregated organic waste can be spread to farmland, but digestate from mixed organic waste has to be used for land restoration rather than being spread to farmland.

5.117 EA approval is required to spread to agricultural land, unless digestate has PAS110 certification. EA approval can be time-consuming, taking eight to ten weeks.

5.118 PAS110 accreditation can help to increase the value of digestate,

5.119 Water companies mentioned an alternative standard, the Biosolids Assurance Scheme, which they hope the EA will accept as evidence that their digestate should be treated as a product rather than waste. This is an alternative to the onerous process of getting EA approval to spread 'waste' on farmland.

Upgrading of digestate

5.120 Respondents reported a variety of methods that had been used to upgrade digestate or reduce handling costs. These included:

- Expressing the liquid fraction to reduce volumes and obtain solid digestate that was easier to handle
- Developing distribution networks

5.121 Solid digestate was costlier to produce but was easier to distribute and could be spread at any time, in contrast to liquid digestate.

5.122 Thermal hydrolysis of feedstocks could also pasteurise and improve the quality of digestate.

5.123 Others had considered investment in ammonia-stripping equipment to improve the quality of products offered to farmers but had decided that this was not currently viable because of the high initial investment required.

Business case not dependent on digestate drying

5.124 No post-reform plants reported use of digestate drying. There was mention of digestate drying by a pre-reform plant, but this was not reported to be a significant part of their business case.

Availability of income from non-RHI revenue streams

5.125 Respondents mentioned three main groups of non-RHI revenue streams, all of which had disadvantages relative to RHI (particularly first tier RHI). These were: gas sales; existing incentive schemes such as ROCs and FiTs; and emerging but currently uncertain revenue from other sources (including CO_2 sales and new incentive schemes such as Green Gas Certificates and Renewable Transport Fuel Certificates). These categories of non-RHI revenue are discussed in turn below.

Fluctuating income from gas sales

5.126 Gas sales were described as the second largest revenue stream in the biomethane business case, after RHI revenue. Respondents reported that they currently represented 20-30% of revenues, depending on whether there was revenue from other sources such as Green Gas Certificates, other incentives or gate fees.

Obviously the main [revenue stream] is the Renewable Heat Incentive, which is comprised of roughly 70%, and then the wholesale price of the gas in green gas certificates. [..] The wholesale is roughly 25%, and 5% for the certificates. (BIOM-Applicant)

5.127 Unlike RHI revenue, gas sales revenue tends to fluctuate over time. Gas prices vary on a daily basis, influenced by the weather and its effect on the supply-demand balance.

5.128 Gas sales contracts tend to be short term compared to the 20-year timeframe for RHI income. Respondents reported that longer term contracts could only be obtained by accepting a low gas price.

You will sign contracts that will give you something in relation to the general market price at the time, but it's not generally possible to fix the price unless you're prepared to fix it at a low rate. (BIOM-Gas shipper)

5.129 Longer term gas contracts also expose the operator to risks that they might not be able to export the required volume owing to problems at the plant.

5.130 Gas sales revenue is usually obtained via a gas shipper, who sells the gas to third parties on the open market and is paid a few for handling the gas.

The shipping agent certainly gives us the price of the [...gas..]. That price, they deduct a small fee for handling the gas, and the gas is then placed into a network and bought on the open market by third parties. (BIOM-Applicant)

5.131 The fluctuation in gas revenues makes their contribution to business cases problematic, because it's difficult to be confident in forecasts of gas prices and revenues.

5.132 While some of the more sophisticated developers consider taking out futures contracts to hedge their risk on gas prices, most simply accept that the revenue stream may fluctuate. Longer term hedging contracts would involve committing to a certain level of gas export, which could be risky in itself, as explained above.

5.133 An added risk here is that the gas network operator can limit off-take from an injection point at any time, which could affect a biomethane operator's ability to export a contracted volume of gas.

Potential income from other sources

5.134 This sub-section explores the income available from past or existing incentive schemes (biogas RHI, ROCs, FiTs, Enterprise Investment Scheme) and then goes on to examine emerging income streams (i.e. Green Gas Certificates, Green Transport Fuel Certificates and CO_2).

Biogas RHI

5.135 Biogas RHI was reported as a minor income stream by plants that used biogas onsite to generate heat (e.g. for pre-treatment of feedstocks or for treatment of digestate). This was not reported to be a significant element of the business case for biomethane plants.

5.136 The introduction of the rule that 50% of feedstock had to come from waste, and the removal of RHI from digestate drying, was likely to limit this further in future.

They [Ofgem/BEIS] are likely to say that any use of heat in maize agriculture is not eligible for the RHI, which is not a huge income stream loss, but a significant one. (BIOM-Applicant)

Renewable Obligations Certificates (ROCs)

5.137 RHI-funded investment in biomethane installations was seen by respondents as an alternative (and successor) to investment in biogas-powered CHP engines that were previously incentivised by other policies, particularly ROCs or the Feed-in-Tariff (FiTs). RHI for biogas/biomethane had increased in importance in recent years because of reduced opportunities for biogas/CHP to obtain ROCs and FiTs income.

5.138 Respondents reported that closure of the ROCs scheme to new entrants reduced the incentives available for generation of electricity from biogas. ROCs were reported to have been more valuable than FiTs, when they were available to new plants. Respondents reported that there was no incentive to add a CHP engine to an existing ROCs-accredited site as the new engine would share the existing ROCs accreditation.

5.139 For recent plants that obtained ROCs before the scheme closed to new entrants, the level of income obtainable from ROCs was low relative to RHI and gas sales.

… four-sevenths of the income is RHI, two-sevenths of the income is gas sales and one-seventh of the income is RO. (BIOM-Applicant)

5.140 For those with existing AD plant, and with high running costs, investment in a biomethane installation with RHI income was seen as an alternative to ROCs as a means of generating income and sustaining the viability of their AD plant.

FiTs

5.141 FiTs were reported to be a minor part of the business case by those applicants that had a Combined Heat and Power engine (e.g. to generate heat and electricity to run the gas to grid facility). The CHP engines were typically 500 kW.

5.142 However, FiTs were reported to have degressed to the point that new investment in CHP plants was not attractive.

5.143 It was reported that this could have the perverse incentive of making investment in natural gas CHP more attractive than investment in biogas CHP.

Enterprise Investment Scheme (EIS)

5.144 The EIS was also mentioned as a previous source of support for biomethane schemes, via the tax reliefs that it provided.

[We] were to build it under the EIS tax incentive scheme, which is easier for risk, but the government took that away. [..] They were building them [biomethane installations] under these EIS schemes before. You could have equity brief schemes, tax relief. (BIOM-Applicant)

Green Gas Certificates (GGCs)

5.145 GGCs were reported to be a relatively low income stream, but with potential to increase in future. Income from the sale of GGCs was generally seen as a bonus to the business case.

It equates to 2%, it's not a major… It's not insignificant, it's a reasonable amount of money but, compared to the other costs and the other elements that are feeding in, it's not that great. (BIOM-Applicant)

5.146 GGCs are bought by firms seeking to improve their sustainability and reduce their reported carbon emissions. The market was reported to be small and prices unpredictable.

5.147 But the size of the market is expected to grow and the value of GGCs are expected to increase in value in future as the value of carbon increases.

At the moment, we're up to something in the order of £4 per certificate, £4 per megawatt [hour]. Those were less than half of that only 12 months ago, so we're starting to see some growth there. (BIOM-Applicant)

5.148 GGCs generated from waste feedstocks sell for slightly higher values than those generated from energy crops, because the blue-chip firms buying GGCs have policies against buying certificates generated from energy crop feedstocks.

Renewable Transport Fuel Certificates (RTFC)

5.149 The Renewable Transport Fuel Obligation (RTFO) requires major suppliers of road transport fuels to use a certain proportion of biofuels, which can include compressed, liquefied biomethane. Respondents reported that there was a small but growing market to sell RTFCs to major retailers or freight companies that operated truck fleets and were seeking to reduce their carbon emissions. The value of RTFCs for biomethane produced from waste was reported to be double that of RTFCs for biomethane from energy crops such as maize. The fuelling station does not need to be close to the biomethane injection point, provided that both are linked by the gas grid.

5.150 One drawback with RTFCs is that they are not paid until the relevant volume of gas is extracted from the grid for use in a vehicle, in contrast to the RHI which becomes payable when gas is injected into the gas grid. The development of the RTFC market is therefore dependent on investment in 'downstream' infrastructure.

5.151 A further drawback mentioned was that RTFCs are a tradable commodity with highly volatile prices, in contrast to the RHI which has a fixed tariff over a 20-year timeframe. This volatility meant that investors would look for higher rewards to compensate for the riskiness of this income stream.

The RHI is a guaranteed tariff which you've secured. Whereas, the RTFO scheme is an openly traded commodity, almost, which has huge price fluctuations. (BIOM-Applicant)

5.152 Renewable Transport Fuel Certificates (RTFC) were therefore seen as an emerging source of subsidy. They were reported to be too uncertain at present to be included in the main business case for biomethane plants, at least for those that would not exceed tier 1 of the RHI biomethane tariff.

5.153 However, investors in large and very large biomethane installations reported that they had negotiated with Ofgem to allow RTFCs to be used as the source of subsidy for production of biomethane above 40 GWh per year (i.e. the threshold for tier 2 tariffs), because RHI rates above this threshold were less attractive than predicted RTFC rates. There were risks inherent in this strategy because of uncertainty about future RTFC prices.

The way to make the finances look slightly better is to operate… We've discussed that with Ofgem to say, "We'll allocate 40GWh over this year to the RHI scheme and the rest- if we produce more, that will go to the other scheme," and that's fine. (BIOM-Applicant)

5.154 For smaller plants, or plants that pay for feedstocks, RTFC prices (at 3.7 p/kWh) were reported to be unattractive given the costs and risks involved in operating these biomethane plants.

5.155 But major investors with large biomethane investments, or food waste investors that operated their own truck fleets for food waste collection, saw RTFC as strategically important to the point that some were investing in refuelling stations.

CO_2

5.156 Biomethane plants using membrane technologies that generate CO_2 that could theoretically capture the CO_2 and sell it as a resource to carbonated drinks companies, to glasshouses (to boost plant growth) or to slaughterhouses (for humane slaughter methods). However, few plants were anticipating generating income from CO_2 sales. Those plants that were hoping to generate some income from CO_2 were those that used membrane technology, used 'clean' feedstocks and were located close to potential markets for CO_2.

5.157 It was reported that carbonated drinks producers wanted CO_2 generated from energy crops such as maize, rather than from food waste, sewerage or animal manure. While this may have been a perceived rather than a real risk, it was reported to be a barrier to marketing CO_2.

5.158 These factors, combined with the investment required to capture and store CO_2, means that income for CO_2 is not a core part of the business case for biomethane plants at present. It is potential upside for the future, if prices or perceptions of risk change.

Insights relating to the supply theory

Evidence of supply bottlenecks

5.159 There was evidence of potential bottlenecks in the supply chain for the cohort of post-reform biomethane plants that need to be commissioned by January 2020 to qualify for Stage 3 of TG approval. There was concern that the RHI and RHI reforms had created a boom-bust situation for biomethane plants.

Each stage there's going to be a bottleneck because the resources available in the industry for doing the commissioning, for providing the GEUs [gas entry units], for liaising with the DNOs, the DNOs, the size of teams they have, how many projects they can deal with at any one time is ridiculous. There's hardly any- from an industry doing no or next to no projects will be delivering 20 big projects. (BIOM-Applicant)

5.160 There was particular concern that equipment supply and gas network connections would become a bottleneck in the run-up to January 2020.

That's our biggest worry, that the suppliers are trying to satisfy too many people at the same time. [..]You've lined everyone up for a roughly similar build timeframe, which means you're automatically lining everything up so that poor old SGN has got a hell of a lot to do around December and January next year. (BIOM-Applicant)

5.161 Investors that were highly concerned about the risk of completing on time, and able to invest at risk, had chosen to spend funds ahead of RHI award to maximise their chances of completion.

5.162 We've ordered our equipment ahead of the time, before we even were awarded our funds, before we were awarded the RHI. We started work on the civils engineering, the groundworks, the earthworks, the foundations of the structures before we even got funded, so we had to provide that money from ourselves, right, to make sure that we keep ahead of the pack. Because it comes- when everybody is going to be wanting to get the plans commissioned, there's not going to be enough resources in the industry. So to protect ourselves from that risk, yes, it's cost us about- we've had to fork out a lot of money. (BIOM-Applicant)

5.163 Uncertainties about the number of RHI plants that would finally get through the approval stages and get built meant that organisations in the supply chain did not know how much capacity they would need to provide.

5.164 Gas network operators with multiple biomethane applications were in a similar situation of not knowing how much organisational capacity they would need to provide in coming months. They reported that a lead-time was needed to get staff in place and train them up, which would make it difficult to expand organisational capacity quickly.

I'm expanding my team. However, it's very difficult to get that justification through my organisation with not actually knowing what I've got to deliver this year. Until I've got firm projects, it's very difficult to resource up. When you do resource up the problem I've got is because they need to connect in a very short time now, how are you going to train those people? I'm in a chicken and egg situation. (BIOM-Gas network operator)

5.165 The gas connection bottleneck was thought likely to be exacerbated by winter conditions in January 2020, when gas demand is relatively high.

Evidence of suppliers entering the market

5.166 As explained in the capital cost sub-section above, equipment for AD and biomethane plants was primarily sourced from other European countries, rather than the UK. Suppliers of equipment were located in Germany, the Netherlands and Austria.

5.167 There was evidence of European suppliers entering the market, including the UK market, because of RHI making biomethane projects viable.

There are certainly more players active in the UK today, and I would say Europe. Yes, I mean, we face certainly more competition than we would have perhaps three, four years ago. That is certainly influenced by RHI because it's the RHI that makes the projects not just profitable but viable. (BIOM-Technology supplier)

5.168 There was some, limited, evidence of biomethane investors focusing on the UK because of closure of the RHI scheme in Northern Ireland.

Evidence of suppliers withdrawing from the market

5.169 There was some evidence of developers withdrawing from the biomethane market because they were unable to achieve a viable business case even with the uplifted tariffs available after December 2016 without compromising on operations costs.

So, we spent the best part, in fact probably over £500,000 getting 3 projects ready for funding, and we haven't managed to get any of those to financial close under the current regime of the RHI. It's not, in our view, enough to run a plant… We don't compromise on operations cost, because you need to invest to a level in your operations to make sure these plants run well (BIOM-AD operator)

5.170 Withdrawals from the AD/biomethane market were reported to bring the risk of skills being lost, in an area which is complex and demanding.

5.171 Alternatives included investment in other clean technologies that were seen to be less dependent on government subsidies, such as electric vehicles, or investment in renewables overseas.

5.172 Where UK technology suppliers had been established in the UK, these were reported to be struggling. Two had entered administration, and one was reported to be at risk.

There are a couple of firms that have come out of the incentives and been created, new technology providers. Three I can think of, but two are already in administration, and a third, well, the third isn't going to build many more plants, it has to change how it operates quite quickly, otherwise it'll go into administration as well. (AD operator)

Insights relating to the fuel and feedstock theory

Evidence of feedstock supplies entering the market

5.173 The 50% waste requirement introduced by the RHI reforms had encouraged biomethane investors to focus on plants that could feasibly meet this requirement. As explained in section 3, there was evidence of plants not being taken forward if they were only viable with energy crop feedstocks. Concern about feedstock supplies was therefore primarily focused on waste feedstocks, particularly food waste which could generate higher gas yields than agricultural waste.

5.174 As described in the feedstock sub-section above, the availability of food waste is a complex area. On the one hand, there are no regulations in England prohibiting food waste from going to landfill, despite regulations applying to Scotland and Wales. This means that some food

waste is still going to landfill (e.g. within household waste). If food waste regulations prohibited disposal to landfill, some respondents suggested that gate fees would increase to cover the costs of alternative forms of disposal.

The situation in England isn't helped, obviously, with landfill still being available. There's a perceived shortage of raw material for some AD plant operators. I must stress that ours are full and we place some material into third parties. (BIOM-Applicant)

5.175 However, in the short term, competition might depress food waste collection margins as the larger food waste collectors compete for market share.

Perversely, I was being told last week that the government announcement just before Christmas about mandatory food waste collection in districts has resulted in post-Christmas the big players, some of whom I've already mentioned to you, have suddenly started a price war halving the cost of food waste collections. Not because they've got lots of profit in it, because they haven't, but in order to get market share ahead of the councils introducing mandatory collections. (BIOM-Applicant)

5.176 Competition between food waste collectors is reflected in downward pressure on gate fees in those parts of the UK where there are multiple AD plants already operating or in the pipeline (including those generating electricity as well as biomethane plants). In these areas, food waste brokers were running food waste collections and competing to supply it to AD plants. Further evidence about the supply of food waste in these areas is set out in the feedstock sub-section above.

5.177 There was also evidence of food waste being transported significant distances to be processed in plants owned by waste contractors, beyond county boundaries.

Evidence of suppliers withdrawing from the market

5.178 While we did not find evidence of feedstock providers withdrawing from the market, we found evidence of limited incentives for the development of new food waste collection.

5.179 Those companies that ran an integrated food collection, AD and biomethane business reported that some form of subsidy was needed to make their business model work for new plants. When ROCs, FiTs and biogas CHP tariffs were available at attractive levels, their business model depended on obtaining subsidies from electricity generation for large-scale biogas CHP plants. As explained elsewhere, RHI for biomethane has provided an alternative business model where a cost-effective gas grid connection can be achieved, but this has become less attractive for large food waste plants since the introduction of lower tariffs for higher rates of biomethane production.

5.180 There was consensus that – unless food waste was banned from landfill and gate fees increased substantially – new investment in food waste processing plants would not proceed without some form of subsidy beyond the end of the RHI scheme.

That was the original [county] requirement with the plan being a number of years ago to roll out food and organic collections across the county to deliver over 100,000 tonnes. There's been no incentive to do that, so it hasn't happened. (BIOM-Applicant)

Insights into wider impacts on agricultural/waste systems

5.181 Evidence about other interactions with wider agricultural and waste systems is explored below.

What feedstock would have been used for otherwise

5.182 There was evidence that some of the feedstock being used for combined AD and biomethane plants would previously have been used sold for use in other AD plants (which produced biogas for electricity generation or biomethane). In these cases, the main impact of building a new AD and biomethane plant was to reduce the transport of feedstock.

5.183 Other waste feedstocks such as sewage sludge and animal slurries would have been spread to land, providing a lower quality bio-fertiliser than digestate.

With agricultural waste, what has been done for thousands of years is that waste from livestock is spread back onto the land. (BIOM-Applicant)

5.184 The availability of feedstocks such as straw were reported to vary widely, with more surplus at some times than others.

Straw isn't so much disposed of. So, the residues that we're using aren't so much disposal things that are other routes for some of that material, but there are big peaks and troughs in the availability of straw. It's an arable area that can easily be a surfeit of straw in the area. (BIOM-Applicant)

5.185 There was also some evidence that maize would have been grown anyway on poorer quality land, as a 'break crop'. In these cases, it was not being planted primarily as an energy crop.

At the moment, we put in maize just to benefit the land. At best you're breaking even, often you're actually losing money off that crop itself but making the money back on the reduced chemicals and the benefit to the land for your wheat that comes on next. Whereas AD plants actually make maize and other break crops a viable crop in itself. It stands alone and had financial value to the wider estate, as well as all the crop rotation and soil and pest benefits that it always had. (BIOM-Applicant)

5.186 However, some respondents were supportive of the introduction of the waste rule, suggesting that growing maize for energy only – where it was not needed as part of a crop rotation system on poorer land – was inappropriate.

5.187 We found no direct evidence that AD/biomethane plants were diverting crop-waste or other waste streams (e.g. brewery waste) from animal feed, but cannot rule out that this is happening.

What would have happened to AD digestate otherwise

5.188 Investment in biomethane upgrade plant for an existing AD plant does not have any impact on the volume or use of digestate as the digestate arises from the AD plant rather than the upgrade plant (see diagram in section 2).

5.189 However, investment in new or expanded AD plant associated with biomethane plants does increase the supply of digestate. As outlined in the 'digestate' sub-section above, we found evidence of potential benefits to farmers from increased use of digestate as a bio-fertiliser, replacing some or all use of petrochemical based fertilisers.

5.190 Farmers' preferences between AD digestate, sewage sludge and other forms of bio-fertiliser were said to vary, depending partly on the needs of their particular soil. A reported benefit of AD digestate was that it contained lime that could kill pathogens.

Now, some farmers like the AD material, some of them like the lime stuff, because it's got the nutrients in it and it's got the lime [..] You know, if a farmer needs to lime his land, then why not take lime as well as organic matter and as well as nutrients? (BIOM-Digestate distributor)

5.191 There was also some suggestion that increased use of digestate had other benefits for agricultural systems, such as soil improvement (from use of solid digestate) and disease management.

It's good for black grass management and keeping on top of certain diseases in the farm. It's a nice business to holistically fit within an agricultural enterprise. (BIOM-Applicant)

Dependencies with other systems/plant

5.192 The evidence set out in sections 4 and 5 above have highlighted that some AD and biomethane investments had inter-dependencies with the business case for other plants as follows:

- **Thermal hydrolysis plants:** AD/biomethane investments were sometimes combined with investment in thermal hydrolysis plants. These plants treated lower quality feedstock streams (including sewage waste and straw) in order to increase gas yields and pasteurise the feedstock. Some investors were effectively considering a combined business case for THP and AD/biomethane plant.
- **Aeration plants:** AD/biomethane investments were sometimes an alternative to renewal of, or expansion of, aeration plants that were previously to treat liquid effluents from sewage treatment or liquid wastes from industrial processes. The business case of the AD/biomethane plant was compared to that of the aeration or effluent treatment process.
- **CHP plants:** The business case for AD/biomethane investments was also commonly compared to the business case for AD/CHP investments that would generate electricity.

Air quality impacts

5.193 We found evidence of AD/biomethane investment reducing transport impacts, as described in the CO_2 section below. Respondents did not mention any direct impacts on air quality.

CO_2 impacts

5.194 Membrane-based biomethane processes produce CO_2. As explained in the CO_2 sub-section above, few plants have yet invested to capture CO_2 and sell this as a product. So, in this sense, biomethane plants were found to have a direct impact on CO_2 emissions, to some degree.

5.195 However, AD and biomethane processes are often a method of disposing of a waste stream that would otherwise produce methane or CO_2.

5.196 Where AD/biomethane is being used as an alternative to an existing aeration process, CO_2 emissions were reported to be significantly reduced compared to emissions from effluent treatment using aeration. This benefit is not currently counted within carbon footprint calculations.

There's a CO_2 scrubber [in the upgrade plant]. Compared to where we're producing CO_2 from aeration process, then it's minuscule compared to [that]. [...] It's a little bit frustrating from a business because the CO_2 we were losing to atmosphere is not in any CO_2 scope. We can't claim CO_2 savings from the process. (BIOM-Applicant)

5.197 Investment in AD and biomethane plants was reported to reduce the carbon footprint of feedstock transport, particularly where feedstocks were previously being transported for long distances to other AD plants.

[Without this biomethane project, this food processing company] would continue to take the feedstock off and truck away at it of a massive carbon footprint in doing so. So, they would continue to sell that into the open market as they do at the moment, there is maybe 15 to 20 lorries turning up per day to cart [it] off site. So, that's the main thing, we are now providing clean energy at source, which takes the strain off the grid, allows us to do less, drop less natural gas and saves a massive carbon footprint in transport. (BIOM-Applicant)

5.198 The low level of FITs incentive for CHP engines was reported to result in some applicants who were adding biomethane production to an existing AD facility switching their CHP to natural gas, involving additional carbon emissions compared to biogas CHP.

5.199 The addition of biomethane production to an existing AD facility also undermines the overall additionality of the carbon benefits associated with biomethane investment. Whilst we know that this practice exists, it is It is not possible to use the application data to reliably quantify it. Data sharing constraints mean that it is also not possible to do so by matching biomethane applications with AD schemes accredited under the FiTs and ROCs schemes.

Odour impacts

5.200 Where AD digestate was produced as an alternative to sewage sludge, it was reduced in both volume and odour.

We reduce what we call [..] our secondary sludge by 90%, so it's almost eliminated. [..] It's early days, we're actually just doing some controlled trials. It's already fairly obvious the odour is

massively reduced, which is logical because it hasn't got any secondary sludge in it. It hasn't got any biological sludge or it's got very little. (BIOM-Applicant)

5.201 However, another respondent reported that newer sewage sludge were also lower odour, saying that some of the issues about these newer sewage sludge may have been perceived rather than real.

5.202 Where odour issues do occur, even with AD digestate, this stakeholder suggested that careful management of spreading frequencies could reduce the nuisance to local people.

5.203 Low-level application systems and storage systems that reduced odour (e.g. by reducing splashing from liquid effluent; or by installing covers for farm storage of digestate) were also reported to reduce the loss of nutrients from liquid digestate.

Wider impacts

5.204 This section highlights a few wider impacts on agricultural systems and the wider environment that have not been covered elsewhere in this report. Many of these wider impacts do not relate exclusively to biomethane but also for other uses of AD.

5.205 For farming businesses, AD was reported to help with diversification, providing a source of income that was less volatile than crop prices. This provided a motivation not just for farmer applicants but also for farmers hosting developer-led schemes.

Farming is very inconsistent in its revenue stream and we have been looking very eagerly for diversification incomes that are more consistent. Well, deliver higher levels of profit and are more consistent. Farming is a very precarious industry, so this enables us to diversify and secure other incomes. (BIOM-Applicant)

5.206 Some stakeholders commented that the wider benefits of AD were under-recognised, not only in terms of improving soil quality and fertility but also in terms of carbon capture in the soil.

If you capture it [organic waste], harvest it, harness it, and put it into the soil, those sort of things are important. We need to be able to have sustainable fertilisers to be able to feed us in 60, 70, 80 years' time and maintain soil quality, and there's also the benefit of capturing carbons and putting those into the soil, improving soil structure. All of those sort of benefits are not recognised. (BIOM-AD operator)

5.207 Plastic pollution was mentioned as a possible wider impact, if plastics in feedstocks (e.g. food waste) find their way through the AD process and into digestate.

6 Future for the biomethane market

Market prospects

Existing/planned biomethane plants

6.1 A number of the cases in our sample were not yet in construction and not all had secured funding for their schemes. Concern was expressed that a number of applicants in this position would not proceed with their schemes and some applicants themselves admitted to concern about being able to secure funding for their schemes given the shortened construction period for their TG schemes.

It's [likelihood of proceeding to completion] about 50/50 at the moment… We were told initially that we had two years to build, then we were told 18 months, now it's down under a year. So, our problem with our funders is about whether or not we can make it in time for the cut-off date of January. That's the major threat to the project. (BIOM- Applicant)

6.2 The timeframes for securing TGs were significantly shortening the construction period for some and it was suggested that the process doesn't always recognise the nature of the process of securing external funding. A 'chicken and egg' situation was described by one applicant, with Ofgem seeking evidence of financial close prior to awarding a TG, but the investor unwilling to commit until the TG had been secured.

6.3 These shortened construction timeframes were seen to present challenges for the supply chain. One technology supplier questioned whether the supply chain could deliver the planned schemes and suggested that they had turned away opportunities to supply schemes because of their own inability to meet the necessary timescales.

Certainly, from the discussions I've had with customers, with other, as I say, colleagues within the sector is the feeling is it's the commission date of 31 Jan 2020 is the risk. Obviously we're already April, so we're nine months away from that date, nobody knows. There are several factors suddenly fall into that, it's obviously you've got to commission through a winter period, nobody knows yet what that winter will be, but beyond that, that numbering itself, 28 units, tariff guarantee, currently sitting on Ofgem's website, it's the ability of manpower, core competence in the market to actually install and commission those units safely. To be honest, that has caused us a major problem, because we know we have had to turn away business because we cannot squeeze the delivery schedules to get the equipment to site in the timeframe they need. (BIOM-Technology supplier)

6.4 Similarly, a gas network operator referred to the prospect of a rush of plants needing to be connected in the winter of 2019, with winter being their busiest time of year, but not knowing how many plants they would need to accommodate due to the delays and uncertainty.

Organisationally, I'm expanding my team. However, it's very difficult to get that justification through my organisation with not actually knowing what I've got to deliver this year. Until I've got firm projects, it's very difficult to resource up. When you do resource up the problem I've got is because they need to connect in a very short time now, how are you going to train those people? I'm in a chicken and egg situation. (BIOM-Gas Network Operator)

6.5 Considerable uncertainty about food waste supply was evident in the data. As noted in section 4, a number of applicants seeking to develop plants do not have long-term supply contracts and some have yet to secure any contract. This may further undermine the likelihood of some plants being delivered. Those plants reliant on food waste that have been or are being developed may also be adversely affected by the increased competition for food waste and the pressure that this is placing on gate fees, even though the alternative disposal routes are financially unattractive.

The industry is in a very parlous state. There are a few plants owned by people with deep pockets that will ride through. There are a lot of plants either falling over or teetering on the edge. When you look at the alternatives to food waste processing landfill, including the tax, is typically about £120 a tonne. Burning it tends to be between £80 and £100 depending on where you're based. Yet you've got anaerobic digestion plant operators fighting for material and killing the price. For those that can't stand it will lead to significant collapse in the number of plants operating. (BIOM-Applicant)

6.6 Conversely, one applicant highlighted the fact that Defra is currently consulting on a proposal to require local authorities to offer all households separate weekly food waste collection by 2023[10]. Should there not be a significant expansion in alternative routes for recycling of this waste, it was suggested that this could lead to increased gate fees and increased profits for plants which take food waste.

6.7 These uncertainties led some respondents to speculate that the number of applicants who would end up not commissioning their plants would be significant.

I think the level of deployment is going to be woefully under what BEIS is hoping for… I would wonder if 50% of those plants don't actually end up being built. (BIOM-AD Operator)

I think we've got now another 28 under tariff guarantee. I don't think 50%, only around 60% a figure of that will probably get commissioned before the end of January 2020. (BIOM-Technology Supplier)

6.8 Concerns were also expressed about the operational effectiveness of some schemes. As noted in paragraph 4.72 there is some concern that short-term expediency in terms of technology choices may undermine longer-term profitability. It was further suggested that, in some cases, the need to attract external investment in a competitive market may have led some developers to compromise on build quality and/or operational budgets, which may lead to financial problems further down the line.

I suppose by compromising on price then you reduce the overall need to generate as much money, but I think in this market there isn't any margin to get it wrong, with the RHI where it is, you know, take two months of downtime because you weren't able to cross a road, or because there was a problem with one of your bits of technology that was unforeseen, or your control

[10] See https://consult.defra.gov.uk/environmental-quality/consultation-on-consistency-in-household-and-busin/supporting_documents/recycleconsistencyconsultdoc.pdf

panel doesn't talk to your injection kit in the way that it should. Whatever reason, and you could very quickly see these plants getting to a point of unable to finance, or pay for the finance that's been agreed, and that's happening quite a bit. (BIOM- AD Operator)

6.9 It was also reported that there are some 'distressed assets' on the market, which are being sold by their developers. It was suggested that such circumstances may be caused by a number of factors including high-cost construction finance and plant performance.

Future biomethane plants

6.10 Degression in the RHI tariff in January 2019 was seen by most respondents to have removed the prospect of any significant further investment in biomethane at the present time. The latest Ofgem RHI statistics, covering the period to June 2019, show that there have been only two active biomethane applications since the tariff degressed by 15% in January, a significant reduction on 2018 application levels. One of these was in June 2019.

6.11 The low number of applications during in 2019 may reflect the approaching tariff guarantee deadline, then understood to be January 2020, as well as the tariff degression. It is not yet known whether many new plants will come forward at the lower tariff rate now that the tariff guarantee completion deadline has been extended to January 2021. It is possible that some applicants may withdraw earlier applications and reapply to take advantage of the extended deadline, even at the lower tariff rate. [11]

6.12 As noted in section 5, RTFCs may provide a basis for investment in the future, but the fluctuating price means that they are currently seen by some as too risky to underpin the necessary investment.

I actually thought that [the RTFO] was, I won't say silver bullet, but I thought once projects were given the green light that they could claim both that would open up just an unlimited number of opportunities, but again I spoke with potential operators who were thinking the same and then when they've looked at the green cert [RTFC] values they just though it's not worth the risk. (BIOM-technology supplier)

6.13 One developer/operator suggested that there focus now would be on consolidation, including responding to the issue, discussed in paragraph 6.8, of some plants being expected to be unable to operate cost-effectively.

There's nothing there that we are looking at at the moment that looks vaguely interesting… So, for our business growth, we're now entering a consolidation phase. We're going to operate plants that are failing. We're taking on plants that are not performing and need to be turned around, and if we get in there in good enough time, we can do that before all the money runs out. So, that's our current focus, is to make the most of what has been built. (BIOM-AD operator)

[11] In May 2019, BEIS announced that the deadline for commissioning of tariff guarantee projects had been extended from 31 January 2020 to 31 January 2021. To benefit from this extension, projects would need to apply (or reapply) at the current tariff rate (i.e. the post January 2019 degressed tariff rate).

6.14 There was an alternative view. The observed CMOs described in section 4 highlight that some of those who do not need to purchase a feedstock and may also have a business imperative to make sustainable use their own waste stream were less reliant on the uplifted tariffs. These could include manufacturers and water companies. It was suggested that such contexts may provide some opportunities for biomethane investment at current RHI tariffs and even in a post-RHI context, particularly if the incentives for electricity production remain low.

The good thing for this market is that it's not so attractive now to do the electricity option. So, there is a chance if you've got a waste, if you're an industrial process with a waste, "What are you going to do with it?" and it could now be that biomethane is not a bad idea. So, the obvious one being sewage. I know there are not many sewage work plants going ahead but, in theory, you would think there should be. (BIOM-Gas Shipper)

In other words, if it becomes a waste disposal issue where someone's got to dispose of this problem stuff, whether it's industrial waste, or food waste, or sewage, and they can't make… there's no subsidy for anything, then they might say, "Well, actually, when I look at it, I would prefer to do the gas to grid one than the CHP one. The reason is, looking forward, a lot of the times the CHP in my electricity might not be worth much, at all, because if it's windy and it's sunny, people won't want my electricity. Whereas, at least, if it's gas, they will always want my gas." So, I think, long-term, you can sort of see if there's those… The relatively small amount of stuff that goes into RHI is where there is no alternative, and you have to do something, then it might be that those projects could still happen without the RHI; but anywhere you've got to buy anything to go in… you know, for any feedstock, it's pretty much never going to be economic, I don't really think. (BIOM-Gas Shipper)

6.15 Some respondents envisaged market prospects for biomethane being enhanced by changes in waste collection regimes, particularly increases in food waste collection by local authorities, which could lead to increased gate fees for such waste. Reference was made to the importance of the 2018 Waste Directive in underpinning such changes.

6.16 The market may be further aided by initiatives by the gas network operators to facilitate grid injection. One such operator referred to exploring ways of enhancing the capacity of parts of their grid, in order to enhance injection opportunities.

We're looking at how can we make… I go back to the flexible network. How can we get more green gas into our network? What do we need to do? We're looking at compression. That's moving gas up pressure tiers to provide a gap within the lower pressure tiers to get their gas away. We're looking at what can we put into our RIIO-2 plan[12]. (BIOM-Gas Network Operator)

6.17 The availability of 'virtual pipelines' may further assist potential biomethane developers by providing remote injection points for their gas. One operator of such a facility suggested that significant latent demand for biomethane development could be opened up by the availability of such facilities. Linked to previous points, one specific source of this latent demand which was

[12] RIIO-2 is the next price controls set by Ofgem for the network companies running the gas and electricity transmission and distribution networks.

identified was water companies currently generating electricity under the ROCs regime. Whilst many sewage treatment works may be poorly located with respect to the gas network, a virtual pipeline model may overcome this barrier.

6.18 Further development of the virtual pipeline model was also mooted in the form of the injection point also incorporating part of the upgrade technology and therefore avoiding the need for a full upgrade plant at the AD site itself. This would enable lower investment by water companies, thereby helping to address a further market barrier, and potentially influencing the level of Government support which would be needed in such cases.

So, if the water industry were to consider removing the [CHP] engines at the end of their ROC life, or end of life, and say, we've still got a source of biogas here, what can we do with it? It's very much a lower incentive they would need to just put a smaller clean-up plant in and run trucks in and out... But they run the rest of their tankage in and out of these facilities anyway, with the sludge in, so it wouldn't be significant. There might be small support, but nothing like the RHI you would need for new plants, if they would need support at all. (BIOM-Injection Plant Owner)

6.19 A similar model was seen as having potential in other sectors such as agriculture too, particularly if the value of the gas were to increase.

So then you could have a low-cost membrane system on farm, and at the point of injection, you could just put another small bank of membranes on the outlet of the trailer feed into the grid, just to scrub out the last bit and clean out the remaining CO_2. And that only needs to get down to 2.5%, so it's just a little polishing membrane before it goes in... That may have traction, because that would give you very low-cost upgrading at source, shall we say, and you could polish up the final bits before it goes into the grid... It could be [viable], because obviously if you keep it at a low cost, you could possibly get the return on gas sales. But if the long-term forecast is 1.5p and upwards going forwards, yes, I think that would be potentially viable. (BIOM-Injection Plant Owner)

Views on future Government support

6.20 Ongoing financial support for biomethane was seen to be important for maintaining investment in the industry. This research, which found that RHI was critical to all business cases examined, supports this view.

6.21 It was further suggested by respondents that the opportunities for significant tariff degressions, in the short term at least, may well be limited due to the nature of biomethane plants and the associated limited opportunities for cost reductions over time. This was seen as being in contrast to other renewable technologies such as wind and solar, where technological advances and economies of scale have generated significant cost savings.

I think the reality, and I think BEIS needs to understand this, is that AD plants are made of concrete and of steel, and of pumps and of engines, but just because a tariff comes down doesn't make any of these things less expensive. (BIOM-AD Operator)

6.22 It was reported that the reliance on biomethane technology from overseas meant that recent falls in the value of sterling, had led to technology costs increasing rather than falling.

6.23 The importance of tariff guarantees in certain contexts has also been clearly illustrated in this research and the importance of ongoing management of the uncertainty brought by degressions, in terms of maintaining both investment and the quality of schemes, was emphasised by some respondents. There was seen to be an incongruity between the quarterly nature of degressions and the time taken for development of biomethane plants. This led one interviewee to suggest that less frequent degressions would be more appropriate for the biomethane tariff.

You've got this constant fear that your project is going to be undermined. I can understand the concept of degression, but why every quarter? It's not like our prices change that fast. Maybe annually, that might be a little bit of a wiser move, but quarterly is just a nonsense. It means you're always looking over your shoulder, and the pressures you then place upon the deployment of these technologies is unfair. It leads you to make bad decisions, both in technologies, in deployment… You know, if you're always under pressure, you've got to sign cheques and get things through the door quicker and cut corners or compromise. So, that's not a way to build an industry. It's not a way to support an industry. (BIOM- AD Operator)

6.24 However, whilst tariff guarantees were broadly welcomed by respondents, the way that they had been implemented and, in particular, the commissioning deadline and associated constraints on construction times generated considerable disquiet amongst respondents.

The concept of having certainty over the rates is a good one. The process they've gone down with the tight timescales and deadlines has made it very challenging. (BIOM-Financier)

6.25 One developer suggested that shorter timeframes for subsidy might be feasible if initial tariffs were higher.

Giving a tariff guarantee for 20 years is mad, in my view. There isn't a commercial funder, or very few, that give you 20 years money. If you can't pay the debt down on the cost of the plant in 10, then I don't think you did the job properly. (BIOM-Applicant)

6.26 Responses highlighted inter-relationships between direct Government incentives for biomethane production and other policies such as:

- the support for electricity generation (FiTs and ROCs) – as discussed in paragraph 6.14 the level and availability of these mechanisms are closely tied to decision-making relating to biomethane;
- transport policy and the RTFO in particular, operated by the Department for Transport, which currently plays a minor role in decision-making relating to biomethane but was seen to have significant future potential to support biomethane investment. It was suggested that having a floor price for RTFCs would enhance their potential role in biomethane investment decisions;

- EU, Defra and Local Authority policy on waste – as discussed in paragraph 6.15, increases in food waste collection were seen to have important consequences for the future viability of biomethane investment;
- regulatory drivers for the Gas Network Operators – as discussed in paragraph 6.16, some of these operators were seeking to facilitate injection to their networks; and
- regulatory drivers for waste producers such as water companies, which could influence waste uses and disposal.

6.27 Given these linkages (and no doubt others), joined-up policy will be important in promoting future growth in the industry. Similarly, the need for consistency across the various authorities involved in supporting and regulating biomethane development (BEIS, Ofgem, the Environment Agency and planning authorities) was emphasised. Of particular concern was the process of gaining RHI approval from Ofgem, which was seen to have hampered the delivery of some schemes.

6.28 The importance of ongoing support for biomethane was emphasised in relation to maintaining the supply chain. It was reported that significant capacity was lost from the supply chain in the hiatus between the reform announcements and the reform implementation and at the time of the research some of those currently involved in the supply chain were looking at overseas rather than UK markets for the future. This was generating concern about future skills and capacity in the supply chain.

The gas industry hasn't really recruited too many new trainees in recent years either, so a lot of people will not only have to decide whether to close down their project development business or not, but a lot of people will probably go, "Well, that's it, I may as well retire now." If everyone thinks, "Well, that's probably it," even if the government comes back two or three years later with a good new policy for ongoing support, they might find that a number of the people and the skills that we've built up aren't really available. A thing that we've seen is that nothing about AD is in fact- incredibly important, incredibly difficult, but nothing about AD is totally straightforward. In order to get good things done, you need a cluster of people who know what they're talking about on quite a few areas… You want continuity and some kind of policy carrying on so that we don't waste the knowledge that we've acquired. (BIOM- Applicant)

7 Appendix A: General contexts

We identified general contexts that would normally need to be in place for any biomethane investment, including some contexts that are specific to each of the main sample groups highlighted above. These contexts have been defined on the basis of information from the policy workshop and from scoping interviews and are presented in the table below. Potential alternative uses/requirements for feedstocks are included as these may affect the business case. Our aim would be to integrate these general contexts into the additionality CMOs when we have a fuller understanding of their importance in biomethane decisions.

Type of investor	Typical feedstock used for biomethane	General contexts necessary for biomethane investment to go ahead	Specific contexts likely to be seen for this type of investor
Farmer-owner	Energy crops, crop waste and/or slurry	Access to feedstock Availability of land for plant Access to land for spreading digestate Costed technology Injection point identified Planning permission for plant EA permit approved Injection point approval Access to internal capital or external finance Previous renewable energy experience (likely)	Own feedstock and land Waste might otherwise be used as soil improver or be used for biogas
Manufacturer-owner	Food waste from manufacturing process ('food soup')		Own feedstock Waste would otherwise be used for biogas or would require disposal
Utility-owner	Sewage waste		Own feedstock, land and significant capital resources Sewage would otherwise be used for biogas
Developer	Any of the above, plus municipal waste		Previous biomethane experience likely Significant capital resources likely Dependent on others for feedstock

8 Appendix B: Candidate CMOs

We now present the CMO combinations for the additionality of biomethane investments with respect to the RHI. We have considered carefully how to define the outcome in this theory. Many of the biomethane applications relate to projects that are not yet close to starting installation or commissioning. We have therefore linked the outcome to the main research question by focusing on how and whether the RHI contributes to the viability of the business case for a particular biomethane installation. By 'viability', we mean a business case that is likely to attract financial investors so that – barring unforeseen problems – the project is likely to proceed.

Our proposed CMOs are summarised in the bullet points below and presented in more detail in the subsequent table. These CMOs are closely based on CMOs 1, 3, 4, 5 and 6 in the overall demand theory for the reformed RHI. There is no biomethane equivalent to CMO2 in the overall demand theory, as this relates to the rebound effect for renewable heat which is not directly relevant to biomethane[13]. As in the overall demand theory, these CMOs focus on whether reformed RHI (or pre-reform RHI) contributed to change that would not have happened without the RHI. In other words, these CMOs focus primarily on distinguishing between different ways in which the RHI may or may not have generated 'additional' outcomes for biomethane installations.

- CMO1a – Reformed RHI contributed to a viable business case for this proposed biomethane installation - not viable without the reformed RHI
- CMO1b – Pre-reform RHI contributed to a viable business case for this proposed biomethane installation - not viable post-reform
- CMO1c – RHI contributed to a viable business case for this proposed biomethane installation – not viable without the RHI, but the reforms were not a major influence
- CMO2 – Irrespective of RHI, there was a viable business case for this proposed biomethane installation – RHI was a windfall
- CMO3 – Pre- or post-reform RHI improved the business case for this proposed biomethane installation but it might have been viable anyway (i.e. a mix of CMO1 and CMO2)
- CMO4 (may be observed alongside any of the other CMOs) – The technology choice, feedstock choice, scale or investment timing of this proposed biomethane installation was influenced by the pre- or post-reform RHI
- CMO5a – the business case for this proposed biomethane installation is still not viable despite the reformed RHI (i.e. other factors mean that this project is still not viable)
- CMO5b – the business case for this proposed biomethane investment is still not viable, despite being approved for pre-reform RHI, and it's unlikely to go ahead

[13] We need to be aware, however, that some installations use some the gas they generate to produce heat which is then used to process their feedstocks. There is a risk that RHI subsidy incentivises inefficient use of this gas.

Candidate theory - CMOs for biomethane demand

Key to whether CMOs are desirable or undesirable from a policy perspective:

Desirable	Neutral	Undesirable

Name	Contexts for additionality/non-additionality of RHI	Mechanism	Outcome
1a. "Reformed RHI contributed to a viable business case for this proposed biomethane installation – not viable without the reformed RHI"	• Provisional TG approved or expected to be approved (Ofgem Stage 1) • Business case unviable, marginal or too risky without reformed RHI • TG perceived as reducing financial risk (enabling Ofgem Stage 2 – financial close) • Business plan sufficiently advanced to meet TG requirements • Have capacity to submit application within required timescale for TGs • Commissioning feasible before TG deadline (31st Jan 2020) • Finance identified, if not approved • Injection site identified • Planning permission in place • EA approvals in place • Suitable feedstocks available (meet 50% waste rule, acceptable cost, reliable quality) • Technology identified and costed	Specific aspects of the RHI reforms (e.g. TG, increased tariff for 50% waste) make the business case for this proposed biomethane installation viable, which would not have been viable without the reforms	Viable business case for this proposed biomethane installation, that would not have been viable pre-reform
1b. "Pre-reform RHI contributed to a viable business case for this proposed biomethane installation – not viable without the pre-reform RHI"	• Business case unviable, marginal or too risky without pre-reform RHI • Business case otherwise well advanced, with good prospects of going ahead eventually • Not viable under post-reform RHI because of (one or more of): • Business plan not sufficiently advanced to meet TG requirements and deadlines (e.g. site, permissions,	The pre-reform RHI made the business case for this proposed biomethane installation viable, which would not be viable post-reform	Viable business case for this proposed biomethane installation, that would not have been viable post-reform

Name	Contexts for additionality/non-additionality of RHI	Mechanism	Outcome
	approvals and/or finance not sufficiently advanced, technology choice not yet made) • Proposed feedstocks don't meet 50% waste rule, and old tariff levels not available post-reform High risk of not being able to commission before TG deadline (31st Jan 2020) Viability dependent on two-stage commissioning		
1c. "RHI contributed to a viable business case for this proposed biomethane installation – not viable without the RHI, but the reforms were not a major influence"	• Business case unviable, marginal or too risky without RHI • Finance identified, if not approved • Injection site identified • Planning permission in place, or close to being in place • EA approvals in place, or close to being in place • Suitable feedstocks available (meet 50% waste rule, acceptable cost, reliable quality) • Technology identified and costed • TG (if approved) improves the business case but not essential for viability • Possibly - business plan sufficiently advanced to meet TG requirements • Possibly - commissioning feasible before TG deadline • Possibly - have capacity to submit application within required timescale for TGs	The RHI makes the business case for this proposed biomethane installation viable. While the reforms have affected our business case (positively/ negatively), they were not critical to the business case (For example, we may have delayed our application to obtain a TG and improve our business case, but this was not critical to viability)	Viable business case for this proposed biomethane installation, if supported by either the pre-reform or post-reform RHI
2."Irrespective of RHI, there was a viable business case for this proposed biomethane installation – RHI was a windfall"	• Business case robust without RHI, using other income streams and/or sources of subsidy (e.g. Renewable Transport Fuel Certificates) • Finance approved or likely to be approved • Injection site identified • Planning permission in place, or close to being in place • EA approvals in place, or close to being in place	The RHI improved our business case but the business case for this proposed biomethane installation was viable and would have obtained financial approval anyway, without RHI	Viable business case for this proposed biomethane installation, irrespective of RHI support

Name	Contexts for additionality/non-additionality of RHI	Mechanism	Outcome
	• Suitable feedstocks available (meet 50% waste rule, acceptable cost, reliable quality) • Technology identified and costed • Possibly has TG, but this may just improve the business case: • TG (if approved) is 'nice to have' but not essential • Possibly - business plan sufficiently advanced to meet TG requirements • Possibly - commissioning feasible before TG deadline • Possibly - have capacity to submit application within required timescale for TGs	The reforms have affected our business case (positively/ negatively) but were not critical to viability	
3. "Pre- or post-reform RHI improved the business case for this proposed biomethane installation, but it might have been viable anyway" (i.e. some RHI influence on business case viability – MIX OF CMO1 and CMO3)	• Mix of the contexts above (e.g. business case strong enough without RHI, but RHI improved it and helped - or will help - to get stakeholders/financiers on board) • OR difficult to say whether it would have gone ahead in the absence of the RHI	The business case for this proposed biomethane installation might have been viable, but the pre/post reformed RHI provided us or our financiers with reassurance (or reduced the perceived risks in our business case).	Viable business case for this proposed biomethane installation that may be partly attributable to the pre/post-reform RHI scheme

Name	Contexts for additionality/non-additionality of RHI	Mechanism	Outcome
4. "The technology choice, feedstock choice, scale or timing of this proposed biomethane installation were influenced by the pre- or post-reform RHI) (MAY BE OBSERVED ALONGSIDE CMOS 1, 2 or 3)	• Some or all of the contexts in CMOs 1,3,4 plus • Technology choice influenced by RHI reforms • Choice of feedstocks influenced by RHI reforms • Size of plant influenced by RHI reforms • Timing of investment influenced by specific aspects of RHI reforms	Specific aspects of the RHI reforms (e.g. TGs, feedstock rule, tariffs) influenced our choice of technology, feedstocks, scale or timing for this proposed biomethane installation. (Note: timing might have been brought forward to benefit from pre-reform RHI, or delayed to obtain post-reform RHI)	Plans for this proposed biomethane installation were changed to improve our business case, given the RHI reforms.
5a."Business case for this proposed biomethane installation still not viable, despite reformed RHI"	One of the following contexts failed: • TG application rejected OR too late to apply for TG • Business case unviable, marginal or too risky, even with reformed RHI • Investors perceive high risk of post-TG degressions • Commissioning not feasible before TG deadline • Finance not identified or not approved • Problems with identifying injection site • Problems with obtaining planning permission • Problems with obtaining EA approvals • Problems with obtaining suitable feedstocks (meet 50% waste rule, high cost, unreliable quality) • Problems with cost or reliability of proposed technology • Other dependencies/risks (e.g. dependent on go-ahead for other projects)	Despite (or even because of) the RHI reforms, the business case for this proposed biomethane project is still not viable. (i.e. RHI is not enough OR TGs no longer available OR other factors mean that this project is still not viable)	Business case for this proposed biomethane installation is not viable, despite RHI reforms.

Name	Contexts for additionality/non-additionality of RHI	Mechanism	Outcome
5b."Business case for this proposed biomethane installation still not viable, despite being approved for pre-reform RHI, and it's unlikely to go ahead"	Approved for pre-reform RHI but one of the following contexts failed: • Original application was speculative • Business case unviable, marginal or too risky, even with pre-reform RHI • Finance not identified or not approved • Problems with identifying injection site • Problems with obtaining planning permission • Problems with obtaining EA approvals • Problems with obtaining suitable feedstocks (meet 50% waste rule, high cost, unreliable quality) • Problems with cost or reliability of proposed technology • Other dependencies/risks (e.g. dependent on go-ahead for other projects)	Despite approval for pre-reform RHI, the business case for this proposed biomethane installation is still not viable. (i.e. pre-reform RHI not enough, OR other factors mean that this project is still not viable)	Business case for this proposed biomethane installation is not viable, despite being approved for pre-reform RHI, and the project is unlikely to go ahead.

9 Appendix C: Systems map

Below is a systems map prepared by CECAN which summarises insights into the investment process for biomethane and biogas. We have drawn upon insights from this systems map in preparing the theory. It provides useful insights into the different income streams and other elements of the business plan for biomethane installations.

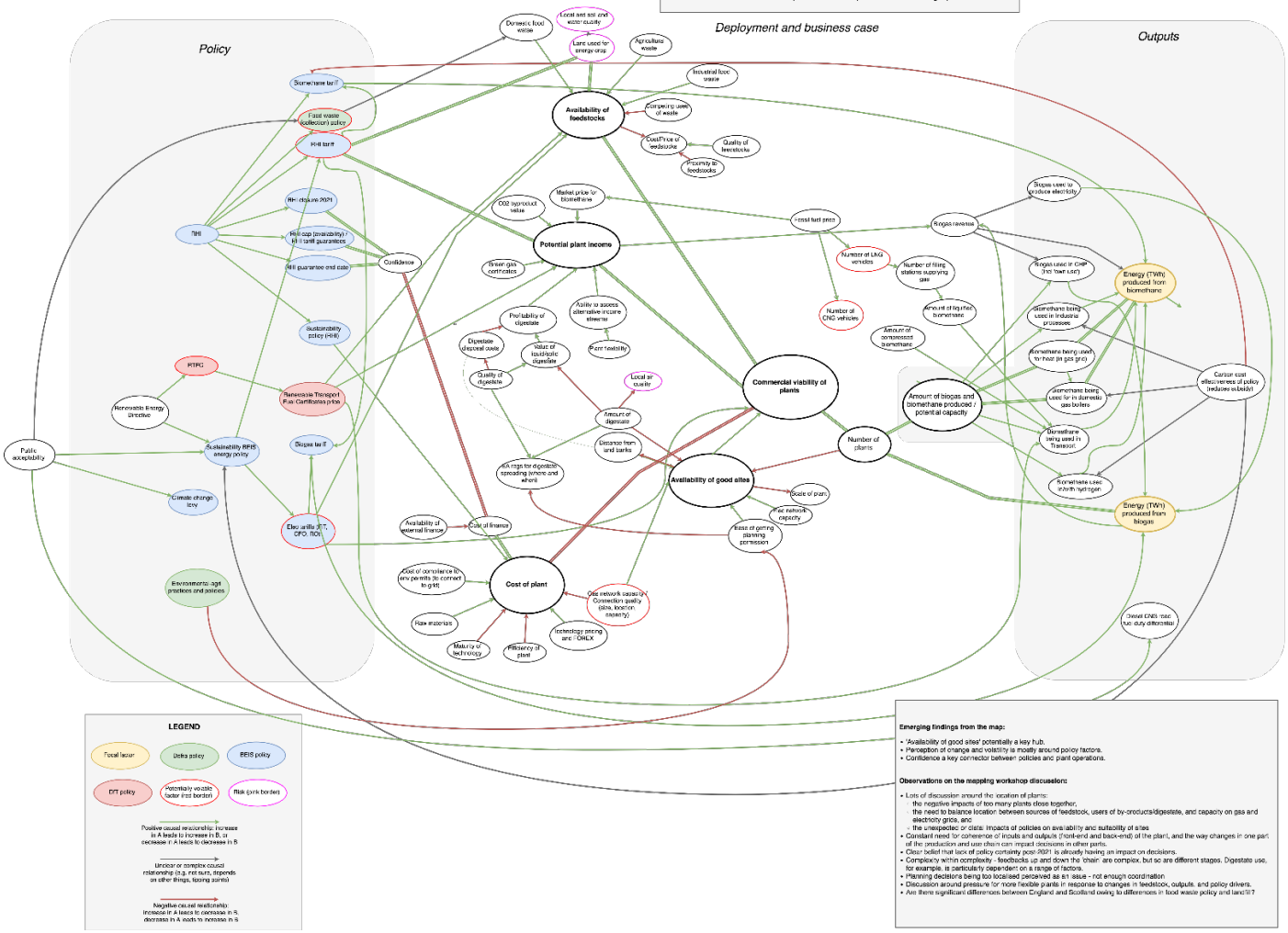
Draft systems map of the biogas and biomethane production and consumption system

Outstanding issues / suggestions for edits:

- Sense check all factors - particularly the policy factors, and output factors - are they all consistent?
- Is there enough detail on policies? Are they all there in a consistent way? BROADLY YES
- Sense check / add contextual factors that influence directly different uses of biogas and biomethane. THESE SEEM ROUGHLY RIGHT
- Should we add more high-level outcomes/objectives - e.g. departmental objectives? I THINK THIS IS FINE FOR NOW
- Do we want to add the Industrial Strategy?
- Add in RIIO factor I THINK THE TEAM SAID THIS WAS MINOR FOR NOW
- Caveat layout - not everything fits perfectly with the 3 sections OK
- What drives land used for energy crop? THE VALUE OF THE CROP MOST LIKELY, SO THAT WILL COME BACK TO THE TARIFFS BEING PAID
- Should domestic food waste be driven by food waste collection policy? yES, DONE
- Can we remove 'cost of biomethane production'? It is represented via other longer paths DONE

RIIO

cecan
Centre for the Evaluation of Complexity Across the Nexus



LEGEND

Focal factor
Defra policy
BEIS policy
DfT policy
Potentially variable factor (not border)
Risk (pink border)

Positive causal relationship: Increase in A leads to increase in B, or decrease in A leads to decrease in B

Unclear or complex causal relationship (e.g. not sure, depends on other things, tipping points)

Negative causal relationship: Increase in A leads to decrease in B, decrease in A leads to increase in B

Emerging findings from the map:

- 'Availability of good sites' potentially a key hub.
- Perception of change and volatility is mostly around policy factors.
- Confidence a key connector between policies and plant operations.

Observations on the mapping workshop discussion:

- Lots of discussion around the 'location of plants':
  - the negative impacts of too many plants close together,
  - the need to balance location between sources of feedstock, users of by-products/digestate, and capacity on gas and electricity grids, and
  - the unexpected or data impacts of policies on availability and suitability of sites
- Constant need for coherence of inputs and outputs (front-end and back-end) of the plant, and the way changes in one part of the production and use chain can impact decisions in other parts.
- Clear belief that lack of policy certainty post-2021 is already having an impact on decisions.
- Complexity within complexity - feedbacks up and down the 'chain' are complex, but so are different stages. Digestate use, for example, is particularly dependent on a range of factors.
- Planning decisions being too localised perceived as an issue - not enough coordination
- Discussion around pressure for more flexible plants in response to changes in feedstock, outputs, and policy drivers.
- Are there significant differences between England and Scotland owing to differences in food waste policy and land?

10 Appendix D: Applicant fieldwork materials

Participant briefing note

Biomethane installations research

1.1 Introduction

The Department for Business, Energy and Industrial Strategy (BEIS) has commissioned CAG Consultants, in partnership with Winning Moves, Hatch Regeneris, EREDA and University College London, to undertake a research project to evaluate the Renewable Heat Incentive scheme (RHI) and understand take-up of renewable heat technologies in Great Britain.

1.2 Information about taking part in the research

As part of this research project, we are carrying out telephone interviews with developers of biomethane installations who were applicants to the RHI.

We will be undertaking telephone interviews in January 2019.

1.2.1 What is the purpose of the research?

CAG Consultants are undertaking a research study to understand the role of the RHI in decision-making around the pursuit of biomethane installations alongside other factors in the marketplace. The impact of the scheme reforms which were announced in December 2016 is a further key aspect of the research.

The research is being conducted on behalf of BEIS. The learning from this research will help to inform future development of policy relating to biomethane. BEIS do not have responsibility for managing the RHI. This is carried out by Ofgem who will not receive individually identifiable evidence from these interviews.

If you wish to validate the authenticity of this research, please contact BEIS at RHI@beis.gov.uk.

1.2.2 Why take part?

The experiences and insights that you share with us in the telephone interview will generate important learning for this study, which will be used by BEIS both to evaluate the Renewable Heat Incentive scheme and to inform future policy on support for renewable heating technology in Great Britain.

1.2.3 What's involved?

We are asking you to take part in a telephone interview which will take up to 60 minutes. It will be an informal discussion, structured around a series of questions. We understand that you may be busy, so we'll organise the interview at a time that suits you.

Interviews will be recorded for research purposes and transcribed. The recordings and transcriptions will not be shared outside the research team.

We plan to share a small sample of interview recordings with BEIS to allow them to carry out quality assurance of the research. We will only share an interview recording with BEIS where we have the interviewee's explicit consent to do so.

1.2.4 What will you ask me about?

We would like to find out in detail about the reasons you decided to pursue a biomethane installation. We'd like to explore the factors that informed your decision and the role of the RHI, and the RHI reforms, in your considerations.

1.2.5 Do I have to answer all the questions?

Taking part is voluntary and you do not have to answer any questions you don't want to. Just let your interviewer know, and they will move on to the next topic. Your interviewer will be happy to answer any questions you have about the research which aren't covered here.

1.2.6 What will happen to my answers?

The findings will be used for research purposes only. We will not pass on your details to organisations outside of the research team. Any interview findings that we use in the research may be linked to other surveys or datasets but the information you provide will be anonymised before inclusion in published outputs. We will keep any information that you share with us confidential and store it securely, in accordance with the Data Protection Act 2018.

You can find out more about how we will use the data from this research in Appendix A below.

This research is not connected to audits for the Renewable Heat Incentive and no identifiable information from the interviews will be shared with Ofgem, the RHI auditors or any other organisation outside of the research team.

The full transcript of your interview will not be shared with the Department for Business, Energy and Industrial Strategy. However, to support the analysis of the interview data, BEIS may receive extracts or summaries of the interview transcripts. This information will not be shared beyond BEIS, and we will endeavour to ensure that interview participants cannot be identified.

1.2.7 Who are your interviewers?

We have an experienced team of professional research interviewers, all part of the CAG Consultants research team. CAG Consultants (www.cagconsultants.co.uk) is an independent research organisation, commissioned to undertake this research by BEIS.

1.2.8 Why have I been selected to take part?

We have selected nine applications which were submitted prior to the reforms becoming effective in May 2018 and nine applications which were submitted after that date. We have also tried to select a cross-section of different types of applications, e.g. those on farms, those within water treatment works, those associated with manufacturing sites and those put forward by developers. This should allow us to gather a good cross-section of views and experiences.

1.2.9 Where can I get more information?

We welcome any feedback you have about your experience with our interviewers. Or, if you have any questions about the evaluation more broadly, please contact Rachel Crozier at rjc@cagconsult.co.uk or 0117 230 6116.

2.10 What if I need to change the interview time or date?

If you need to change the time or date of the interview, please contact Rachel Crozier at rjc@cagconsult.co.uk or 0117 230 6116.

1.2.11 What if I change my mind about taking part?

If you do not wish to take part in this study, please contact Rachel Crozier at rjc@cagconsult.co.uk or 0117 230 6116 to opt-out of the research.

Privacy Notice

Privacy Notice for the evaluation of the reformed Renewable Heat Incentive project

- The data controller is the Department for Business, Energy & Industrial Strategy (BEIS). You can contact the BEIS DPO at: BEIS Data Protection Officer, Department for Business, Energy and Industrial Strategy, 1 Victoria Street, London SW1H 0ET. Email: dataprotection@beis.gov.uk
- The Contractor for the evaluation of the reformed Renewable Heat Incentive is CAG Consult LLP (trading as CAG Consultants), a limited liability partnership registered in England under number OC374324. You can contact CAG Consultants' Data Protection Officer at 150 Minories, London, EC3N 1LS. Email: privacy@CAGConsult.co.uk.
- BEIS and its Contractor will be processing your personal data solely for research purposes.
- BEIS are collecting your data as part of their public task, and CAG Consultants are processing your data on behalf of BEIS.
- We (CAG Consultants) may share your personal information with the Associates that we are using to help us deliver the research. Where we do this, we require them to comply with our data protection protocols, and only process data in the ways described in this privacy notice. Our subcontractors for this contract are:
  - o Winning Moves o Hatch Regeneris o EREDA Consulting
  - o University College London o Rachel Crozier
- We may share your personal information with other third parties where required by law, or where we have another legitimate interest in doing so, for example:
  - o electronic survey service providers
  - o off-site archiving and storage facilities o IT (including back-up) services
- All our third-party service providers are required to take appropriate security measures to protect personal information about Data Subjects in line with the law. We do not allow our third-party service providers to use the personal data of Data Subjects for their own purposes. We only permit them to process such personal data for specified purposes and in accordance with our instructions.
- Your personal data will not be shared or disclosed to any other party outside BEIS and the Contractor without your explicit consent.
- CAG Consultants use some processors whose servers and offices are located in the USA, so your personal information may be transferred to, stored, or processed in the USA. These processors participate in, and have certified their compliance with, the EU-U.S. Privacy Shield Framework. They are committed to subjecting all personal information about Data Subjects

received from European Union member countries in reliance on the Privacy Shield Framework, to the Framework's applicable principles.

- The personal information you provide will be erased from any computers, storage devices and storage media held by the Contractor after the expiry of the Contract.
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Applicant topic guides

See Annex A2

11 Appendix E: Stakeholder fieldwork materials

Participant briefing note

Biomethane installations research

1.1 Introduction

The Department for Business, Energy and Industrial Strategy (BEIS) has commissioned CAG Consultants, in partnership with Winning Moves, Hatch Regeneris, EREDA and University College London, to undertake a research project to evaluate the Renewable Heat Incentive scheme (RHI) and understand take-up of renewable heat technologies in Great Britain.

1.2 Information about taking part in the research

As part of this research project, we are carrying out telephone interviews with those who have a relationship with biomethane installations which have been the subject of applications to the RHI. This includes feedstock suppliers, landowners, financiers, equipment suppliers, digestate users, gas network operators etc.

We will be undertaking telephone interviews in February 2019.

1.2.1 What is the purpose of the research?

CAG Consultants are undertaking a research study to understand the role of the RHI in decision-making around the pursuit of biomethane installations alongside other factors in the marketplace. We are interested in understanding the impact of the RHI and what would have happened in its absence. For example, would any installations have gone ahead? how would the feedstock have otherwise been used? The impact of the scheme reforms which were announced in December 2016 is a further key aspect of the research.

The research is being conducted on behalf of BEIS. The learning from this research will help to inform future development of policy relating to biomethane. BEIS do not have responsibility for managing the RHI. This is carried out by Ofgem who will not receive individually identifiable evidence from these interviews.

If you wish to validate the authenticity of this research, please contact BEIS at RHI@beis.gov.uk.

1.2.2 Why take part?

The experiences and insights that you share with us in the telephone interview will generate important learning for this study, which will be used by BEIS both to evaluate the Renewable Heat Incentive scheme and to inform future policy on support for renewable heating technology in Great Britain.

1.2.3 What's involved?

We are asking you to take part in a telephone interview which will take 30-45 minutes. It will be an informal discussion, structured around a series of questions. We understand that you may be busy, so we'll organise the interview at a time that suits you.

Interviews will be recorded for research purposes and transcribed. The recordings and transcriptions will not be shared outside the research team.

We plan to share a small sample of interview recordings with BEIS to allow them to carry out quality assurance of the research. We will only share an interview recording with BEIS where we have the interviewee's explicit consent to do so.

1.2.4 What will you ask me about?

We would like to find out in detail about the nature of your involvement in the biomethane installation. If you have been involved in more than one, we will inform you of the one we are focusing on, although we will also be interested in your wider views and experiences. We would like to explore how you came to be involved, what the benefits of being involved are, and the role of the RHI, and the RHI reforms, in your involvement.

1.2.5 Do I have to answer all the questions?

Taking part is voluntary and you do not have to answer any questions you don't want to. Just let your interviewer know, and they will move on to the next topic. Your interviewer will be happy to answer any questions you have about the research which aren't covered here.

1.2.6 What will happen to my answers?

The findings will be used for research purposes only. We will not pass on your details to organisations outside of the research team. Any interview findings that we use in the research may be linked to other surveys or datasets but the information you provide will be anonymised before inclusion in published outputs. We will keep any information that you share with us confidential and store it securely, in accordance with the Data Protection Act 2018.

You can find out more about how we will use the data from this research in Appendix A below.

This research is not connected to audits for the Renewable Heat Incentive and no identifiable information from the interviews will be shared with Ofgem, the RHI auditors or any other organisation outside of the research team.

The full transcript of your interview will not be shared with the Department for Business, Energy and Industrial Strategy. However, to support the analysis of the interview data, BEIS may receive extracts or summaries of the interview transcripts. This information will not be shared beyond BEIS, and we will endeavour to ensure that interview participants cannot be identified.

1.2.7 Who are your interviewers?

We have an experienced team of professional research interviewers, all part of the CAG Consultants research team. CAG Consultants (www.cagconsultants.co.uk) is an independent research organisation, commissioned to undertake this research by BEIS.

1.2.8 Why have I been selected to take part?

We have selected 18 RHI applications which were submitted following the announcement of reforms to the scheme in December 2016. We have tried to select a cross-section of different types of applications, made at different times (before and after the main reforms were implemented in May 2018). This should allow us to gather a good cross-section of views and experiences.

1.2.9 Where can I get more information?

We welcome any feedback you have about your experience with our interviewers. Or, if you have any questions about the evaluation more broadly, please contact Rachel Crozier at rjc@cagconsult.co.uk or 0117 230 6116.

1.2.10 What if I need to change the interview time or date?

If you need to change the time or date of the interview, please contact Rachel Crozier at rjc@cagconsult.co.uk or 0117 230 6116.

1.2.11 What if I change my mind about taking part?

If you do not wish to take part in this study, please contact Rachel Crozier at rjc@cagconsult.co.uk or 0117 230 6116 to opt-out of the research.

Privacy Notice

Privacy Notice for the evaluation of the reformed Renewable Heat Incentive project

- The data controller is the Department for Business, Energy & Industrial Strategy (BEIS). You can contact the BEIS DPO at: BEIS Data Protection Officer, Department for Business, Energy and Industrial Strategy, 1 Victoria Street, London SW1H 0ET. Email: dataprotection@beis.gov.uk
- The Contractor for the evaluation of the reformed Renewable Heat Incentive is CAG Consult LLP (trading as CAG Consultants), a limited liability partnership registered in England under number OC374324. You can contact CAG Consultants' Data Protection Officer at 150 Minories, London, EC3N 1LS. Email: privacy@CAGConsult.co.uk.
- BEIS and its Contractor will be processing your personal data solely for research purposes.
- BEIS are collecting your data as part of their public task, and CAG Consultants are processing your data on behalf of BEIS.
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  - o Hatch
  - Regeneris o
  - EREDA
  - Consulting
  - o University College
  - London o Rachel Crozier
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  - o off-site archiving and storage
  - facilities o IT (including back-up)
  - services
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Stakeholder topic guides

See Annex A2

CAG CONSULTANTS

Founded in 1983, CAG Consultants is an independent, employee-owned co-operative. We provide support, research and analysis, policy advice and training in a wide range of fields relating to sustainable development and climate change. We have practitioners in stakeholder & community involvement, regeneration, evaluation, economics and regulatory affairs. We deliver high quality, innovative and thoughtful work for our clients, who include government departments, local authorities, public agencies, the NHS and regeneration and community planning partnerships across the UK. We pride ourselves on our strong ethical approach and our commitment to social justice and improving and protecting the environment.

CAG Consultants' Quality Management System is approved to the Quality Guild standard.

For more information, see **www.cagconsultants.co.uk**