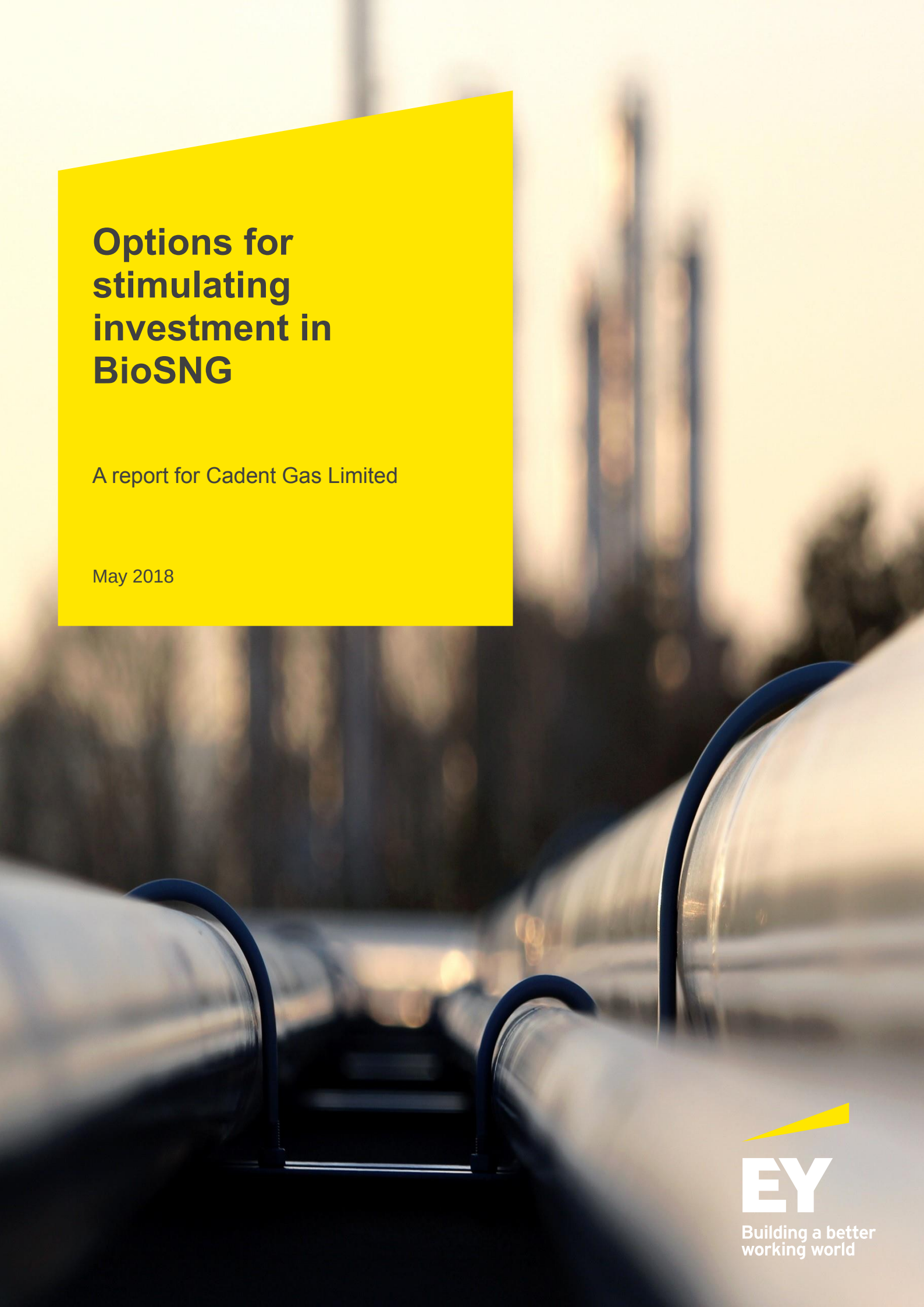
Options for stimulating investment in BioSNG

A report for Cadent Gas Limited

May 2018



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Decarbonising energy is a subject that we at Cadent are both passionate and excited about, and we are using innovation to find solutions for the future of gas. Our stakeholders are very clear when they tell us that the least disruptive solution, and at the lowest cost, is what they need when it comes to decarbonising the challenging areas of heat and transport.

This feedback both supports and complements our ongoing commitment to BioSNG technology which can help decarbonise without the need to change appliances or install major new infrastructure. BioSNG converts residual waste streams and other sustainable bio-resources into green gas. This gas can be put straight into the gas pipe network for immediate use directly in our homes, businesses and in the transport sector.

Putting the gas into the grid makes it highly flexible; it can be stored to respond to market conditions and to support daily and seasonal demand variations. This simplicity, flexibility and efficiency does not exist when the same feedstocks are burnt to make power and heat.

We expect the BioSNG technology that is currently in development will be a game changer, presenting an opportunity for significant emission savings. With such benefits, fast and effective roll out will be required, and will need the right support mechanisms. In order for us to hit the ground running, our aim is to progress the commercial and regulatory thinking in parallel with the development of the plant.

We have therefore commissioned this report, which reviews the experiences to date in supporting similar investments and operations, and identifies those frameworks that could offer the best support for BioSNG. We can then explore these further with policy makers.

We do not have all of the answers to this great challenge, and undoubtedly we will make greater in-roads when we gather the views and thoughts of those around us. Any feedback will be greatly appreciated to help shape the debate going forward.

Thank you for your support.

Chris Train

Chief Executive
Cadent Gas Ltd.

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Executive Summary

Decarbonisation of heat and transport will be key steps towards meeting the United Kingdom's (UK) 2050 targets under the Climate Change Act. There are a number of ways that heating can be decarbonised, including using electricity for heating, adopting heat networks, and/or using the existing gas transportation networks to ship low carbon gases such as Bio-Substitute Natural Gas (BioSNG) or hydrogen to end-consumers.

There is a nascent BioSNG industry in the UK, with a number of trials and pilots of the production technology under way. The results to date are promising, but if BioSNG has a significant role to play in the future of heat and transport in the UK (recognising that viable BioSNG technology would be able to make a valuable contribution to decarbonising the heat and transport sectors) then policymakers and regulators may have an important role to play in facilitating and supporting investment in BioSNG production plants.

Recognising this is an area in need of further exploration, Cadent has commissioned EY to identify and assess possible ways that government could facilitate and support investment in BioSNG plants, once the technology has been proven at a commercial scale. Cadent has not asked EY to make a firm recommendation on a single best way for government to support BioSNG as the most appropriate approach will depend on a range of factors, not all of which are known yet. Rather Cadent has asked EY to short-list a number of options for the industry[1] to consider further over the coming months, alongside the continued evolution of the technology used in the BioSNG production process.

Options for stimulating investment in BioSNG plants

There are potentially a wide range of approaches that might be taken to support investment in BioSNG plants. These options range from relatively limited forms of intervention, placing more reliance on market forces to stimulate investment, through to options that reduce the role of markets and competition and instead regulate the production of BioSNG by existing gas distribution networks.

Drawing on the types of mechanisms which government has deployed to support low-carbon technologies in other sectors, and the particular characteristics of investments in BioSNG, several detailed options for supporting BioSNG can be identified. The options which are considered in this report are summarised in Table 1 below.

Table 1: List of potential options for stimulating investment in BioSNG plants

Option	Description
A. Government support	
A1	**Government guarantee of project debt:** Government provides guarantees of private sector loans to BioSNG projects, making it easier for projects to attract debt and equity investment. The costs of support are borne by taxpayers.
A2	**Government grant:** Government provides a financial grant at the outset of the project, making it easier to attract debt and equity investment. The costs of support are borne by taxpayers.
B. 'Top-up' payments	
B1	**Fixed premium to market price of gas:** Fixed top up payments to BioSNG projects for each unit of gas produced, over and above revenues from the sale of BioSNG produced. The top-up payment is calibrated to take into account expected revenues from gate fees. The payments are funded by gas suppliers, and passed on to gas consumers via their bills.
B2	**Variable top-up linked to market price of gas:** Variable top-up payments to BioSNG projects, on top of the market price of gas, to allow projects to earn a stable total price per unit of BioSNG produced. The top-up payment is calibrated to take into account expected revenues from gate fees. The payments are funded by gas suppliers, and passed on to gas consumers via their bills.

[1] Broadly defined to include government (both national and local), Ofgem, gas distribution networks (GDNs), potential investors in BioSNG, the BioSNG supply chain, consumers, taxpayers and other interested stakeholders.

Option	Description
B3	**Fixed top-up for low carbon gas production capacity:** Payments to BioSNG projects for each unit of capacity available to produce BioSNG, in addition to any revenues earned for the sale of BioSNG produced and from gate fees. Payments are set via a competitive auction. The payments are funded by gas suppliers and ultimately passed on to gas consumers via their bills.
B4	**Higher gate fees for acceptance of waste from Local Authorities (LA):** LAs are obligated to send a proportion of household waste to BioSNG plants, and LAs pay gate fees for each unit of waste used to produce BioSNG. BioSNG projects also earn revenues from the sale of BioSNG produced. LAs will pay higher gate fees because the amount of waste LAs will be required to dispose of to BioSNG will be set at a higher level than the available capacity of BioSNG plants. The costs of support are borne by LA taxpayers.
C. Guaranteed offtake arrangements	
C1	**Guaranteed offtake arrangements:** Government or a third party enters into a contractual obligation to make payments to a BioSNG project at a pre-determined price per unit of BioSNG produced, regardless of the amount of gas produced. The payments are calibrated to recover the costs of the project and a fair rate of return for the risks borne. The payments are ultimately passed on to gas consumers via their bills.
D. Regulated Business Models	
D1	**Fixed long term regulated revenue stream:** BioSNG plants are a licensed and regulated activity, subject to a fixed long-term regulated revenue stream. The revenue stream could be determined by competitive auction and could be payable based on availability to produce BioSNG (rather than actual production). The payments are ultimately passed on to gas consumers via their bills.
D2	**Fixed long-term cap and floor regulated revenue stream:** BioSNG plants are a licensed and regulated activity, subject to a cap and floor on their revenues. The BioSNG project is guaranteed to earn a minimum level of revenue, but can potentially increase its revenues through higher sales of BioSNG in the market and via higher gate fees. The revenue stream could be determined by Ofgem after reviewing a business plan application from the project developer. The payments are ultimately passed on to gas consumers via their bills.
D3	**Long-term regulated revenue stream, subject to periodic reset:** BioSNG investments are undertaken by the Gas Distribution Networks (GDNs) as part of their existing regional monopoly regulated activities. The existing RIIO regulatory framework could be extended to cover these activities, potentially with some bespoke adjustments reflecting specific performance targets for, and asset lives of, BioSNG plants.

Evaluation of potential options for stimulating investment in BioSNG plants

The choice between the different options for supporting BioSNG ultimately depends on whether the given option delivers the objectives of the various stakeholders in BioSNG. The objectives of these different groups are likely to be myriad and complex, and potentially inconsistent with each other, as Table 2 below summarises.

Table 2: Criteria for evaluating options to stimulate investment in BioSNG

Stakeholder	Potential objectives
All	► **Effectiveness** – the proposed support mechanism should enable efficient investment in BioSNG to come forward on a sufficient scale to enable decarbonisation of heat to play its expected role in the UK meeting its decarbonisation targets.
Customers and taxpayers	► **Value for money and competition** – the proposed support mechanism needs to encourage investment in BioSNG at the lowest overall cost (in present value terms), and BioSNG should only receive support if it can compete with other approaches. The duration of the intervention required, and the ability to close the support scheme down at some point in the future, may therefore be important. ► **Fairness** – the burden of paying for the cost of the support mechanism should fall on those who benefit from BioSNG and who are best able to afford the cost.
BioSNG investors and developers	► **Simplicity** – the proposed support mechanism should be simple to understand and administer. ► **Reasonable risk-adjusted returns** – the proposed support mechanism should enable investors (both debt and equity) to expect to earn a reasonable rate of return on their investment for the risks borne. ► **Revenue stability and predictability** – a mechanism which leads to more stable and predictable revenues may be preferable for investors (particularly debt investors). ► **Protection against asset stranding** – the proposed support mechanism should protect investors against asset stranding (including from political and/or regulatory risk).

Stakeholder	Potential objectives
	► **Protection against unforeseen costs** – the proposed mechanism should provide an appropriate degree of protection against unforeseen cost shocks and/or costs not decreasing over time as quickly as expected.
Government (national and local) and regulator	► **Ease and pace of implementation** – a support mechanism that was easier and quicker to implement (e.g., did not require legislative change) might be preferred by government and regulators. ► **Innovation** – the support mechanism should encourage innovation in BioSNG, enabling technology costs to decrease and the ultimate removal of the support mechanism in the longer term. ► **Supply chain & industrial strategy** – a mechanism that supports development of a UK BioSNG supply chain might be preferred by government if it was believed that exports of this technology could be a valuable part of the UK's industrial strategy.

Note: some factors which may be important to stakeholders, such as environmental considerations, have not been included above as all of the options are assumed to be designed in a way that leads to BioSNG being deployed equally effectively and therefore enabling these other objectives to be delivered by all of the options.

These criteria reflect that there are trade-offs between the objectives of the different stakeholder groups and that careful judgements would need to be made. For example, the benefits of providing stronger support to BioSNG projects in the short term would need to be weighed against ensuring that appropriate incentives are in place to drive innovation and cost reductions over the longer term, which in turn would be vital to securing net-benefits for domestic gas consumers and taxpayers (in present value terms) and stimulating a BioSNG export industry that might align with the UK's industrial strategy.

This report focuses on assessing the options qualitatively, noting that the objective of this report is to identify options for further more detailed investigation (rather than to perform that detailed investigation now).

As Table 3 below shows, and as is to be expected, there are advantages and disadvantages to each of the options. However, the options which provide the least protections against commercial risks (Options A1 and A2) may provide too little support to BioSNG because private investors would still be exposed to commercial risks around revenues and costs unless a significant portion of the project's capital would be contributed or underwritten by government. Government may be unlikely to contribute such a large amount of funding to BioSNG projects noting that recent support programmes have aimed to leverage the majority of funding from the private sector on the back of targeted financial contributions from government. For example, the government's Heat Network Investment Programme (HNIP) consultation indicated that it hoped to draw in an additional £2bn of capital investment on the back of £320mn funding from government (meaning government funding would amount to around 14% of total capital required).[2]

Of the remaining options for supporting BioSNG, there are trade-offs between protecting investors against risks in the short term and ensuring that market forces are harnessed to drive BioSNG costs down over time. Or, put another way, there are trade-offs between the contributions that bill payers and taxpayers make, and the risks allocated to them in the short-term and the benefits which they would hope to reap in the longer term. Securing the best value for money overall will require carefully allocating risks to the parties best placed to bear them. This will be necessary to protect investors against those risks which fundamentally undermine the case for investment in BioSNG, but at the same time to expose them to an amount of risk which they can bear and which incentivises the investors to drive innovations and costs savings over time, as well as maximising revenues from the gas market and gate fees. For example:

► The options which provide the most protection to investors (Options C1, D1 and D3) are more likely to stimulate investment in BioSNG and have the lowest cost of capital, but come at the cost of losing some benefits from competition (although the regulation

[2] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/560597/HNIP_consultation_response-Final.pdf, pp5-6.

should aim to introduce competition where possible, and can make use of incentives and penalties), maximisation of revenues from gate fees and any efficiencies and innovation which exposure to market forces might create; and

- The options which provide some commercial protection, but still leave some exposure to market forces (Options B1, B2, B3, B4 and D2) would be more likely to drive innovation and efficiencies over time, possibly making it more likely to enable withdrawal of support for BioSNG faster (as the technology may mature more quickly) than in Options C1, D1 and D3, but come at the cost of a higher cost of capital.

Government is likely to want to be able to gradually withdraw support over time as BioSNG technology matures (and becomes more cost competitive with other technologies), so is likely to want to expose BioSNG projects to some market forces in order to stimulate innovation and cost reductions. Options C1 and D1 might therefore be less likely to be acceptable to government because they may not deliver long term value for money for taxpayers and gas bill payers.

Government and Ofgem have typically favoured competitive bidding for support packages or regulated revenue streams in recent years (such as through Contracts for Difference (CfDs) for renewable power generators, the Capacity Market auction, Offshore Transmission Owner (OFTO) licence auctions or for Competitively Appointed Transmission Owner (CATO) projects), rather than expanding the remit of regulated monopoly gas and electricity networks. Ofgem has also recently been resistant to electricity networks investing in battery storage projects.[3] There may, therefore, be some reservations about Option D3 as a longer term solution, i.e., after initial First of a Kind (FOAK) plants have been delivered.

Recent government support schemes for renewable electricity have favoured the use of a CfD whereby prices per unit of generation are 'topped up' (or reduced) to the wholesale power price, rather than applying a fixed additional payment (like the Renewables Obligation (RO) which was the predecessor to the CfD).[4] Option B1 might therefore be less attractive than Option B2.

However, because options which continue to expose BioSNG to market forces are a weaker form of support for BioSNG than making it a fully regulated activity, the risks that these options would not stimulate investment in BioSNG – at least in the short term – are higher. The higher likelihood of stimulating investment in BioSNG provided by a fully regulated revenue stream would need to be weighed against any lower long-term value for money that such an approach might provide (noting that the fully regulated nature of the activity may mean it is less likely to stimulate innovation and cost reductions over time than support which continues to expose BioSNG to market forces).

Noting all of the above, in our view, a number of options are worthy of further consideration by policy makers and other stakeholders seeking to stimulate investment in BioSNG:

- Options B2, B3 and D2, which provide some protection against extreme market risks, but which still expose investors to market forces, may provide an appropriate medium-term balance of risk between stakeholders that is capable of delivering the best balance of short term value for money and long-term innovation and efficiency. These options also potentially enable a degree of competition between investors seeking financial support, helping to achieve value for money for stakeholders; and

- Option D3 may enable BioSNG investments to come forward faster than any of the other options, as GDNs may be willing to invest in this technology (noting the number of GDNs

[3] See https://www.ofgem.gov.uk/publications-and-updates/enabling-competitive-deployment-storage-flexible-energy-system-changes-electricity-distribution-licence

[4] We note that the National Audit Office recently suggested that the Hinkley Point C nuclear project could potentially have been delivered at a lower cost if alternative arrangements for financing this project had been considered: see https://www.nao.org.uk/wp-content/uploads/2017/06/Hinkley-Point-C.pdf. However, we consider that this recommendation was specific to that particular project rather than a general suggestion that the use of CfDs should be reduced and/or that government should generally contribute a greater share of capital to projects.

currently participating in trials and pilots of BioSNG or other green gases) and there appear to be relatively few barriers to implementation. GDNs could be allowed to propose these investments as part of RIIO-GD2 business plans, or even over the remaining years of RIIO-GD1, for Ofgem to review and evaluate through the price control process. To maximize the benefits of supporting BioSNG in this way, Ofgem and other stakeholders should ensure that the benefits of the lessons learned from those early investments are made available to other potential developers.

If Options B2, B3 and/or D2 ultimately proved to be the most appropriate way(s) to stimulate BioSNG, support via Option D3 could be withdrawn, but the options are not mutually exclusive and there may be benefits to supporting BioSNG through multiple channels. These options should be considered further by government, Ofgem and the wider industry if it is decided to develop a strategy to support investment in BioSNG.

The assessment of the options described above is summarised in Table 3 below to provide a basis for broad comparison.

Table 3: Evaluation of options for stimulating investment in BioSNG plants

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Customers and taxpayers										
Value for money (long-term)	◔	◔	◑	◕	◕	◑	◑	◑	◕	◑
Fairness	◔	◔	◕	◕	●	◑	●	●	◕	◑
BioSNG investors and developers										
Simplicity	●	●	◑	◑	◑	◕	◑	◑	◑	◕
Rate of return[5]	◔	◔	◑	◑	◕	◑	◕	◕	◑	◕
Revenue stability and predictability	○	○	◑	◑	◕	◑	●	●	◑	◕
Protection against asset stranding	◔	◑	○	○	◑	○	●	●	◕	●
Protection against unexpected costs	○	○	○	○	○	○	◑	◑	◑	◕
Government and regulators										
Ease of implementation	◕	◕	◑	◑	◑	◑	◑	◑	◑	◕
Innovation	●	●	◕	◕	◕	◕	◔	◔	◑	◔
Supply chain & industrial strategy	◔	◔	◑	◑	◑	◑	●	●	◑	●

Key:

○ No contribution ◔ Limited contribution ◑ Moderate contribution ◕ Significant contribution ● Strong contribution

[5] For this evaluation criterion: a higher rate of return is considered a “weak contribution” and a lower rate of return a “strong contribution”.

1. Introduction

The Climate Change Act 2008 provides a legally binding target for the United Kingdom (UK) to reduce greenhouse gas emissions by at least 80% by 2050, compared to the 1990 baseline. A key step towards meeting these targets will be to reduce emissions from space and water heating for buildings, which accounts for 20% of the UK's greenhouse gas (GHG) emissions,[6] and from transport, which accounts for around a quarter of the UK's GHG emissions and affects air quality at the roadside.[7] These emissions will need to be largely eliminated by 2050 to meet the Climate Change Act target.[8]

In the UK, heating is currently mainly fuelled by natural gas (gas).[9] There are a number of ways that heating can be decarbonised, including using electricity for heating, adopting low carbon heat networks, and/or using existing infrastructure to transport low carbon gas, such as Bio-Substitute Natural Gas (BioSNG)[10] or hydrogen, to homes, businesses and industry to be used for heat in a similar way to the natural gas that is used today.[11]

Decarbonising heating and transport through increased use of BioSNG, and other low-carbon gases, could be the least cost approach if barriers to deployment of this technology can be overcome. Cadent Gas Limited (hereafter referred to as Cadent), as part of the gogreengas project, has explored the case for investing in BioSNG technology previously and believes that BioSNG has a significant role to play in the future of heat and transport in the UK.[12] If this is true then government, as with other low carbon energy sources, may have an important role to play in facilitating and supporting investment in BioSNG plants.

Recognising this is an area in need of further exploration, Cadent has commissioned EY to identify and assess possible ways that government could facilitate and support investment in BioSNG plants, once the technology has been proven at a commercial scale. Cadent has not asked EY to make a firm recommendation on a single best way for government to support BioSNG as the most appropriate approach will depend on a range of factors, not all of which are known yet. Rather Cadent has asked EY to short-list a number of options for the industry[13] to consider further over the coming months, alongside the continued evolution of the technology used in the BioSNG production process.

This report therefore describes a number of different ways in which government could support the BioSNG industry and its supply chain, and then assesses these against a selection criteria to identify a subset of options that may be appropriate for Cadent, the wider gas industry, policy makers and economic regulators to consider further in future.

Many of the options considered in the report could be applicable to different types of low carbon grid gases, but the focus of the report is on discussing possible ways to support investment in BioSNG.

The remainder of the report is structured as follows:

[6] CCC (2016), Next steps for UK heat policy https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf
[7] UK Government, https://www.gov.uk/government/policies/transport-emissions
[8] CCC (2016), Next steps for UK heat policy https://www.theccc.org.uk/wp-content/uploads/2016/10/Next-steps-for-UK-heat-policy-Committee-on-Climate-Change-October-2016.pdf
[9] BEIS (2017), Digest of UK Energy Statistics (DUKES): natural gas https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/632523/Chapter_4.pdf
[10] BioSNG is a low carbon gas produced through a process of gasification and catalytic conversion applied to household waste and other low carbon feedstocks
[11] Ofgem (2016), Ofgem's Future Insights Series The Decarbonisation of Heat https://www.ofgem.gov.uk/system/files/docs/2016/11/ofgem_future_insights_programme_-_the_decarbonisation_of_heat.pdf
[12] gogreengas (2015), BioSNG Demonstration Plant, Project Close-Down Report, http://gogreengas.com/wp-content/uploads/2015/11/BioSNG-170223-1-Project-Close-Out-Report.pdf
[13] Broadly defined to include government (both national and local), Ofgem, gas distribution networks (GDNs), potential investors in BioSNG, the BioSNG supply chain, consumers and other interested stakeholders

- Section 2 discusses the potential role that BioSNG could play in future, the current state of the market and why government support for investment in BioSNG may be appropriate;
- Section 3 considers options for support mechanisms to bring forward investment in BioSNG, describing each option and how it would work for BioSNG at a high level; and
- Section 4 evaluates the different options for supporting BioSNG and sets out our recommendation on which options should be considered further by policy makers and other stakeholders.

2. BioSNG and the potential need for government to support investment

BioSNG is a low carbon gas produced through a process of gasification and catalytic conversion applied to household waste and other low carbon feedstocks.[14] Because BioSNG reduces carbon emissions significantly compared to existing natural gas, the increased substitution of BioSNG for natural gas in the UK would provide a number of benefits:

- **Decarbonisation of heating and transport** – the benefits of using BioSNG as a low carbon source of heat have been recognised for a number of years. It is estimated that BioSNG can generate substantial lifecycle carbon dioxide savings (typically 80%) compared with fossil fuel alternatives, increasing to 142% if the feedstocks used to produce the BioSNG are diverted from landfill and to 252% if the carbon dioxide produced in the process sequestered.[15]

- **Reduced volumes of waste going to landfill** – residual household waste can be used in the production of BioSNG, which would otherwise be headed for landfill. Diverting waste from landfill can reduce demand for limited landfill capacity,[16] and avoid landfill tax.[17]

- **Reduced cost of energy** – total energy system costs could be reduced by £3.9bn per annum and over £46bn in total by 2050 through the gradual growth in BioSNG production to 100TWh per annum, compared to a scenario without BioSNG, according to National Grid's Energy Strategy and Policy Group.[18]

- **Spillover benefits –** not all benefits from investment in commercial scale BioSNG plants will be realised by the investor or the consumer; some benefits will accrue to the industry as a whole and society more generally. These benefits (externalities) include:

    - The production and the use of BioSNG in the GB energy and transport sectors will diversify the gas and transport fuel supplies, and reduce dependence on imports; and

    - Deployment of BioSNG plants will begin to develop a supply chain, which other BioSNG project developers will benefit from. There may also be opportunities for the UK to export the BioSNG technology developed to supply the domestic industry, and/or to boost production with imports of feedstocks.

To date, despite these potential benefits, current technological and commercial barriers mean that there has only been limited investment in BioSNG technology and it is not yet widely used in large quantities for either heat or transport.

[14] The process through which BioSNG is produced comprises five key stages: fuel preparation, thermal treatment, cooling and cleaning, gas conversion and purification. The fuel preparation stage is a process by which to prepare the feedstocks for thermal treatment (stage two). This involves drying, shredding and removing of recyclates. Now that the fuel is compatible for thermal treatment, it is gasified (heated with controlled amounts of oxygen) and converted into syngas (to later be converted into biomethane). Before it can be converted into a natural gas, tars in the syngas are reformed and it is then cooled and cleaned to remove contaminants such as tars and heavy metals. Lastly, a combination of catalysed reactions, convert the syngas into a natural gas. The unwanted gases are then removed to purify the gas, allowing it to be injected into the gas network: see gogreengas (2015), BioSNG Demonstration Plant, Project Close-Down Report, http://gogreengas.com/wp-content/uploads/2015/11/BioSNG-170223-1-Project-Close-Out-Report.pdf

[15] gogreengas (2017), BioSNG Demonstration Plant Project Close-Down Report http://gogreengas.com/wp-content/uploads/2015/11/BioSNG-170223-1-Project-Close-Out-Report.pdf

[16] Suez (2017), Mind the Gap UK residual waste infrastructure capacity requirements http://www.sita.co.uk/wp-content/uploads/2017/09/MindTheGap20172030-1709-web.pdf

[17] HMRC (2017), Landfill Tax rates https://www.gov.uk/government/publications/rates-and-allowances-landfill-tax/landfill-tax-rates-from-1-april-2013

[18] gogreengas (2017), BioSNG Demonstration Plant Project Close-Down Report http://gogreengas.com/wp-content/uploads/2015/11/BioSNG-170223-1-Project-Close-Out-Report.pdf

BioSNG producing technology is yet to be proven at commercial scale, however, a number of trials and demonstration projects are underway in the UK. For example, Cadent, along with its partners Progressive Energy, Advanced Plasma Power and Carbotech, have developed a BioSNG pilot plant.[19] The project, which started construction in March 2014 and was completed in 2015, has successfully validated the technical feasibility of BioSNG production. The project also enabled developers to not only assess the costs of the technology for this project, but to also forecast what costs may be for commercial scale BioSNG plants in the future.[20]

The findings from the pilot project have led to a decision to construct the world's first large scale BioSNG plant, which will convert 10,000 tonnes of waste per annum into 22GWh of BioSNG, to be injected into the local grid in 2018.[21] The £25mn facility is being funded by a consortium of Cadent, Advanced Plasma Power, Progressive Energy, Wales and West Utilities and CNG Services with support from the Department for Transport Advanced Biofuels Competition and Ofgem's Network Innovation Competition.[22]

The interest in investing in BioSNG is also demonstrated by the number of BioSNG projects in operation, or under construction, across Europe, as summarised in Table 4 below.[23]

Table 4: Selected global BioSNG projects

Project	Description
GoBiGas Phase 2 Gothenburg, Sweden	The facility commenced operation in March 2014, and methane produced by the facility was first injected into the gas network in December 2014. The facility has an installed capacity of approximately 20 MWth, which can produce 160 GWh/year of BioSNG.[24] The project received funding from the European Commission's NER300 funding programme for innovative low-carbon technologies.
BioProGReSs – Biomass Product Gas Reforming Solutions Gothenburg, Sweden	BioProGReSs is a 3 year €5.3mn project, which aims to develop, implement and demonstrate advanced syngas cleaning based on chemical looping reforming in both a pilot and an industrial scale BioSNG plant. In addition, a novel measuring technique developed will be tested and implemented in order to monitor and control the gasification process. In December 2016 the solution was installed at the GoBiGas plant, enabling the measurement of changes in the level of the detected tars. This technical breakthrough has potential to transform monitoring and control of biomass gasification processes in the future.
SNG Demonstration Güssing, Austria	The Biomass CHP Plant started operation in 2002, and has a fuel capacity of 8 MW. The plant demonstrates the complete value chain from woody biomass to SNG. R&D work over the first eight years of operation focused on gas conditioning and SNG synthesis. The pilot scale showed that fluidized bed SNG synthesis is possible. The whole process chain reached high conversion efficiencies, and has the potential for lower investment and lower operational costs than conventional SNG synthesis technology.

At this stage, however, BioSNG technology has not yet matured and is currently relatively more expensive than traditional natural gas. For example, the gogreengas BioSNG pilot project developers conducted an assessment of commercial plant financial performance based on modelling of the technical performance of large scale facilities and estimates of their capital and operating costs and estimated that the levelised cost[25] of a FOAK BioSNG

[19] gogreengas, http://gogreengas.com/
[20] gogreengas (2015), BioSNG Demonstration Plant, Project Close-Down Report, http://gogreengas.com/wp-content/uploads/2015/11/BioSNG-170223-1-Project-Close-Out-Report.pdf
[21] gogreengas (2015), BioSNG Demonstration Plant, Project Close-Down Report, http://gogreengas.com/wp-content/uploads/2015/11/BioSNG-170223-1-Project-Close-Out-Report.pdf
[22] gogreengas, Background http://gogreengas.com/commercial-plant/background/
[23] European Technology and Innovation Platform, BioSNG projects in Europe http://www.etipbioenergy.eu/value-chains/conversion-technologies/advanced-technologies/biomass-to-gas/BioSNG-projects-in-europe
[24] See https://gobigas.goteborgenergi.se/English_version/About_GoBiGas
[25] The Levelised Cost of a technology is the discounted lifetime cost of ownership and use of a generation asset presented in a £/MWh basis. The Levelised Cost is the ratio of the total costs of a plant (including both capital and operating costs), to the total amount of production expected to be generated over the plant's lifetime. Both are expressed in net present value terms meaning that future costs and outputs are discounted, when compared to costs and outputs today. The estimated levelised cost discussed here takes into account receipt of gate fees.

plant producing 315GWh per annum would be £50/MWh. By comparison, monthly average day-ahead natural gas prices have ranged from £8.68/MWh to £29.85/MWh since 2009,[26,27] well below the estimated levelised cost of a FOAK BioSNG plant. In addition, the monthly average day-ahead baseload contract price has averaged £45/MWh since 2010.[28]

Further investment in BioSNG will be required – as has occurred in other sectors, such as renewable energy technologies – to drive the learnings and efficiencies necessary to bring down costs to a level that is competitive with other sources of gas (particularly once the externalities of carbon emissions are taken into account). For example, the gogreengas BioSNG pilot project developers estimated that the levelised cost of BioSNG would fall from the estimated FOAK costs to £21/MWh for an Nth of a kind BioSNG plant producing 665GWh per annum.[29]

However, at the moment, there are a number of commercial barriers to the deployment of commercial-scale BioSNG technology to enable this to happen. The primary commercial risk inhibiting the development of BioSNG is uncertainty around the revenues which an investment in a BioSNG plant would generate from sales of low carbon gas (and to a lesser extent from gate fees for accepting household waste).[30] At this time, any investor in BioSNG would be unlikely to be able to secure an offtake agreement (like a Power Purchase Agreement (PPA) that might be negotiated by a merchant power plant) that would be sufficient to cover the costs of a commercial scale BioSNG plant, making it challenging to attract either debt or equity capital to finance the project (assuming revenues from gate fees would not be sufficient on a standalone basis). If investment in commercial scale BioSNG plants is to occur, some intervention in the market will be required to provide support to bridge the gap between the current cost of BioSNG and natural gas, enabling efficiencies to be achieved to drive costs down to the expected Nth of kind cost.

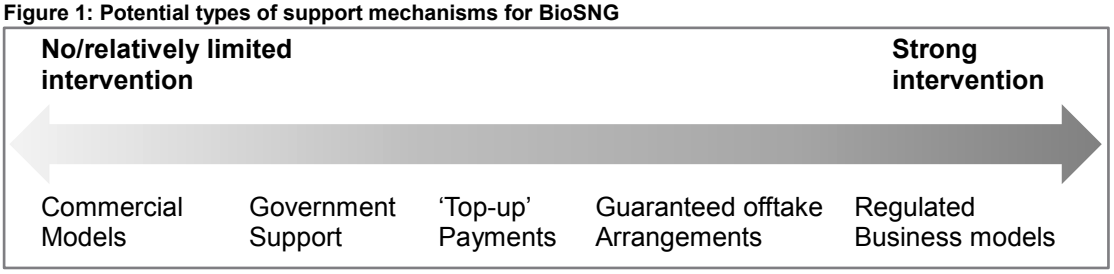
Cadent has told us that it is exploring how to overcome the technological risks separately and this report does not consider those issues. Instead, this report considers how different kinds of policy or regulatory tools might be deployed to enable investment in BioSNG to take place on a commercial scale. The next section describes a number of potential mechanisms that might be employed for this purpose.

[26] Ofgem (2018), Gas prices: Day-ahead contracts – monthly average (GB) https://www.ofgem.gov.uk/data-portal/gas-prices-day-ahead-contracts-monthly-average-gb
[27] Calculated using a conversion rate of 1 therm to 0.029MWh.
[28] Ofgem (2018), Electricity prices: Day-ahead baseload contracts – monthly average (GB) https://www.ofgem.gov.uk/data-portal/electricity-prices-day-ahead-baseload-contracts-monthly-average-gb, average calculated over June 2010 to December 2017.
[29] gogreengas (2015), BioSNG Demonstration Plant, Project Close-Down Report, http://gogreengas.com/wp-content/uploads/2015/11/BioSNG-170223-1-Project-Close-Out-Report.pdf
[30] As noted above, a BioSNG plant could earn revenues from gate fees for feedstocks. However, some of the feedstocks which a BioSNG plant might use would not necessarily attract gate fees, so it is possible that at least for some BioSNG plants gate fees may actually be zero.

3. Options for stimulating investment in BioSNG

There are potentially a wide range of approaches that might be taken to support investment in BioSNG plants. These options can be thought of as lying on a spectrum (as set out below) ranging from relatively limited forms of intervention, placing more reliance on market forces to stimulate investment, through to options that reduce the role of markets and competition and instead encourage and regulate the production of BioSNG by existing gas distribution networks.

Figure 1: Potential types of support mechanisms for BioSNG



Building on the above, the different potential support mechanisms can be thought of as belonging to different 'families':

1. Commercial models;

2. Government support, for example grants and guarantees to underpin private sector investment;

3. 'Top-up' payments, whereby government funds directly, or mandates funding by end-customers of, additional payments to BioSNG either via a higher payment for gas produced or higher gate fees;

4. Guaranteed offtake arrangements, whereby government or a third party commits to purchasing all BioSNG produced at a pre-determined price; and

5. Regulated business models, whereby investment in BioSNG becomes a regulated activity delivered by the GDNs or by other licenced parties.

There are a number of different options within each 'family' of support mechanism, i.e., these mechanisms could be designed and applied in a variety of ways. However, at this stage, rather than explore every possibility in detail, our focus has been on exploring the different 'families' and some of the possible ways that mechanisms could be applied in practice.

The following subsections introduce a selection of options; how each would work to support investment in BioSNG plants is briefly described to allow for a high level assessment of each option and a broad comparison between them, in line with the scope of the report. Further work would, at a future date, be required to consider all of the details of how these options might be designed in practice.

As explained above, the options considered in this report do not constitute an exhaustive list, and there are other potential options to support investment in BioSNG plants that have not been included. For example, extending and expanding the Renewable Heat Incentive or the introduction of a universal carbon tax (e.g., as advocated by Professor Helm in his recent Cost of Energy Review)[31] are other options which could have been considered.

However, introducing a universal carbon tax extends well beyond the gas, heat and transport sectors (rather than being a mechanism targeted at BioSNG) and would therefore require

[31] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/654902/Cost_of_Energy_Review.pdf, page viii.

consideration of a wide range of issues beyond the scope of this report. And while the Renewables Heat Incentive (RHI) for non-domestic installations currently supports BioSNG,[32] given the government has not confirmed funding for the RHI beyond the current Spending Review period, i.e., after March 2021,[33] this report has focused on alternative or supplementary measures which could be introduced to support BioSNG.

3.1 Commercial models

A BioSNG plant operating without any policy, regulatory or financial support would first need to source equity and debt funding to cover the construction costs of the plant. Then the plant owners would need to find an off-taker to sell the BioSNG to, potentially similar to a Power Purchase Agreement (PPA) or tolling agreement, to cover the operational costs of the plant and the financing costs.

For a BioSNG plant to be financeable under this model, a counterparty would need to be willing to commit to buying BioSNG from the plant at a price that covered the plant's costs (net of gate fees), for the duration of a multi-year agreement. However, this would be unlikely to be possible if a potential off-taker did not have confidence that there would be demand for BioSNG from its customers.

Currently it is the case that these customers are unlikely to demand BioSNG for heating at a price required to make the BioSNG financeable; this price is multiple times higher than the price of natural gas that is currently traded in GB, as illustrated by gogreengas's estimated cost for a FOAK commercial BioSNG plant described in the previous section.

Some form of support or assistance is therefore likely to be required to successfully stimulate investment in BioSNG in a timely manner.

3.2 Government grants and guarantees

Government could choose to provide direct financial support for BioSNG plants through a grant, or indirectly through guarantees for debt funding. Both options are discussed in turn below.

3.2.1 Option A1: A government guarantee of the project's debt

Recognising that even when BioSNG plants have been technologically proven at commercial scale it may be challenging for developers to attract debt funding on reasonable terms because of the risks associated with a technology that is not yet mature, a government-backed guarantee on the project's debt funding – whereby the government effectively guarantees to repay the debt investor if the project cannot – would make it easier for a BioSNG developer to attract low cost debt funding.[34] The project may be able to attract more debt at a lower cost with the support of a government guarantee, reducing the overall cost of capital of the project and making it easier to attract both debt and equity capital to finance the upfront construction costs.

Under a guarantee scheme, a developer of a BioSNG plant could then apply for a government-backed guarantee for its debt funding as long as the project met the eligibility criteria, including whether the project is financially credible, delivered greenhouse gas savings and constitutes value for money. BioSNG plant owners would have to meet their obligations to debt investors, in the same manner as under the commercial model, and government guarantee may be triggered if the plant defaulted.

[32] DECC (2014), RHI Biomethane Injection to Grid Tariff Review https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/384202/Biomethane_Tariff_Review_-_Government_Response_-_December_2014.pdf

[33] BEIS (2016), The Renewable Heat Incentive: A reformed scheme Government response to consultation https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/577024/RHI_Reform_Government_response_FINAL.pdf

[34] A variant on this approach would be for the government to lend money directly to the project. By requiring a lower interest rate on the loan than commercial lenders, the government could help to make the project more attractive for other investors.

There are numerous examples of projects that have been supported by government guarantees and the government operates a UK Guarantee Scheme (UKGS) for nationally significant infrastructure, which has to date issued nine guarantees on the principal and interest payments, totalling £1.8bn of Treasury-backed infrastructure bonds and loans, supporting over £4bn worth of investment. These examples could serve as a template for BioSNG to follow and given the UKGS can issue up to another £38.2bn of guarantees until at least 2026, this could potentially be an option open to BioSNG if the projects met the criteria for the UKGS.[35]

3.2.2 Option A2: A government grant

An alternative way that government could support BioSNG projects would be by contributing capital directly in the form of a grant. For example, a grant for the development, construction, and operation of a commercial scale BioSNG plant could be offered by the government. Developers could compete for the grant, and be assessed on price and delivery against a set of government's objectives. The grant would be in addition to revenues earned from the sale of BioSNG in the market and any gate fees for disposal of household waste, and would aim to cover any projected shortfall in revenues over the lifetime of the project, when compared to projected lifetime costs, and could be available during the construction phase of the plant.

Since the grant would be unlikely to cover the entire capital costs of the project (as requiring other investors to have some capital at risk would incentivise them to manage the project efficiently), other investors would still need to fund the remaining costs (meaning the project might still not go ahead unless private sector investors were prepared to commit to it). However, the grant would lower the overall financing costs of the project and make it more likely the BioSNG project would meet the hurdle rates for private sector investors.

An example of a proposed government grant was the now terminated Carbon Capture and Storage (CCS) Commercialisation Competition. This programme proposed to provide £1bn of capital funding, together with additional operational funding to be provided through a CfD to support the design, construction and operation of the UK's first commercial-scale CCS projects. The government ultimately decided to close the competition in 2016.[36] This indicates that for government grants to be a realistic option as a support mechanism for BioSNG plants, government would have to be convinced of the need for support and committed to providing the grant.

3.3 'Top-up' payments

Government could also support investment in BioSNG plants by allowing regular payments to BioSNG plants once they are commissioned to be funded by gas consumers or taxpayers, in addition to the revenue earned from the sale of BioSNG in the market and any gate fees. There is a range of ways in which this could be done, including:

- A fixed premium to the market price for each unit of BioSNG produced;
- Variable top-up payments for each unit of BioSNG produced, linked to the market price of natural gas; or
- Fixed top-up payments for low carbon gas production capacity, paid by gas consumers; or
- Fixed top-up payments for low carbon gas production capacity, paid by local government taxpayers.

These options are explored below.

[35] UKGS is available for nationally significant gas infrastructure projects, and consideration is given to whether projects are financially credible, ready to start construction, and represents value for money. See: Infrastructure and Projects Authority and HMT (2017), UK Guarantees Scheme https://www.gov.uk/guidance/uk-guarantees-scheme
[36] BEIS (2015), UK carbon capture and storage: government funding and support https://www.gov.uk/guidance/uk-carbon-capture-and-storage-government-funding-and-support

3.3.1 Option B1: A fixed premium to the market price of gas

Given that the barrier to investment in BioSNG is that the revenues the project could earn from BioSNG are too low to make the project commercially viable, 'topping up' the market revenues by adding a fixed premium to the market price for BioSNG could help to cover the difference between expected lifetime costs of a BioSNG plant, and expected total revenue from selling BioSNG.

In its simplest form, the premium would be set by government, and differentiated across different low carbon gas production technologies to make up the difference between expected lifetime costs of the technology, and expected total revenue from selling the low carbon gas and gate fees. Producers of low carbon gas, including BioSNG, would apply to receive a fixed premium to the market price they receive for selling BioSNG, for each unit produced, for a set period of time (e.g., the life of the plant). If the premium is calibrated appropriately, it would be expected to make up the difference between market prices and the BioSNG plant's net costs, enabling BioSNG producers to sell their gas at prices that would be competitive with alternative forms of gas, e.g., natural gas. The cost of the premium could be levied upon gas suppliers, in proportion to their customers' gas demand, which suppliers would then pass onto their customers, i.e., gas bill payers.

This mechanism could be developed if government were to introduce a target for the percentage of gas from low carbon sources (including from BioSNG plants) that gas suppliers sell to their customers. A certification system could be established whereby the government decides how many certificates a unit of low carbon gas is worth depending on the type of technology used or associated greenhouse gas emissions. Sub-targets could be developed to ensure that the most is made of existing plants[37], while also supporting less mature technologies. Suppliers would need to buy the certificates from producers of low carbon gas to demonstrate their compliance. A penalty would be charged to non-compliant suppliers.

A variant on the above would be to let the value of the certificates be determined by the market. If the target exceeds the available quantity of low carbon gas the market would be short and the certificate value should be close to the buy-out price. If the target was lower than the available quantity the market would be long and the price would be set by the costs of gas production.

Clearly, such 'top up' payments would make investment in BioSNG more attractive. Whether the mechanism would be successful in bringing forward appropriate BioSNG investments (rather than too few or too many) would depend on whether the finer details of the way the mechanism is calibrated are appropriate, e.g., the size of the target and the relative economics of BioSNG and other forms of low carbon gas.

[37] Setting sub-targets for the existing plant cohorts allows the premium to be fixed for technologies for a specific period of time

Case study 1: the Renewables Obligation

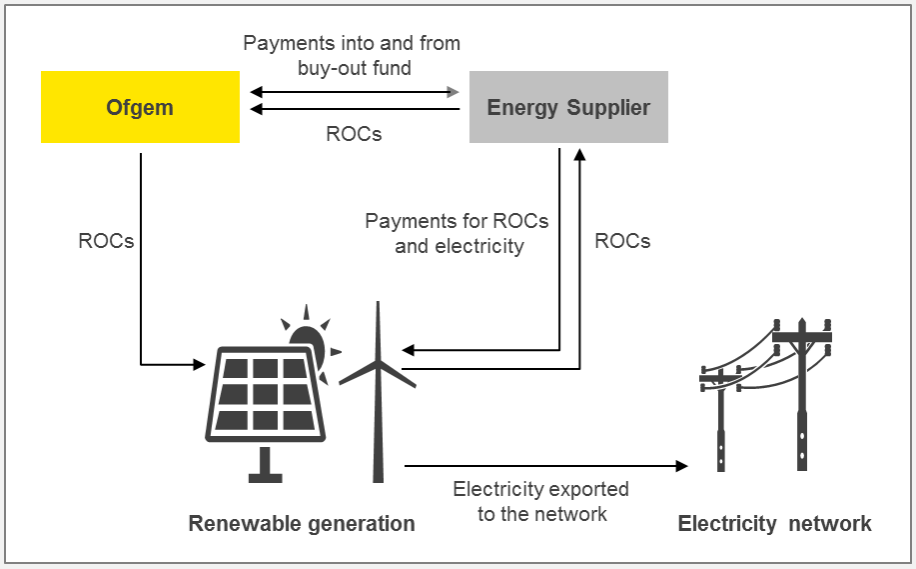
The arrangements described above would be similar to the Renewables Obligation (RO), a support mechanism introduced in the UK in 2002 which provides a premium, i.e., top-up payment, in addition to the wholesale power market price, for large-scale renewable electricity projects. Renewable generation supported by the RO generated 23.4% of the total electricity supplied to the UK in 2015-16. The scheme was closed to all new generating capacity on 31 March 2017, but is still honoured for existing generation plants that have been operating under the RO.[38]

The RO requires electricity suppliers to source a set percentage of the electricity they supply to customers from renewable sources each year, therefore creating demand for renewable energy. The total obligation on electricity suppliers is determined by the Department for Business, Energy & Industrial Strategy (BEIS) every year, and set in terms of the number of Renewable Obligation Certificates (ROCs) an electricity supplier must have per MWh supplied.

Generators receive a set proportion of a ROC for each MWh of renewable energy generated depending on the type of renewable technology type used, which is set by BEIS. These ROCs are then purchased by electricity suppliers. ROCs can either be purchased from renewable generators or from the traded ROCs market. The revenue received by the generator for the ROCs is in addition to the market price they achieve for selling the electricity generated. The price of the ROC is variable, and is set by the supply and demand conditions the ROCs market; the obligation level is set so there would be more demand for certificates than expected supply thereby giving the ROCs value.

Electricity suppliers who cannot demonstrate a sufficient number of ROCs to meet their obligation within the annual compliance period must pay into a fund, called the buy-out fund. The amount paid into the buy-out fund is determined by the number of ROCs the supplier fell short by, and the buy-out price per ROC set by Ofgem. The amount in the fund (post deductions for administrative costs) is distributed back to all electricity suppliers participating in the scheme, proportionately to the number of ROCs they demonstrated in meeting their individual obligation within that period. The net cost of the RO to the supplier is passed onto their customers through retail electricity tariffs.

Figure 2: Stylised electricity, ROC and payment flows under the RO



[38] Ofgem (2017), Renewables Obligation, https://www.ofgem.gov.uk/environmental-programmes/ro

Case Study 2: the Renewable Transport Fuel Obligation (RTFO)

The arrangements described above would also build on the Renewable Transport Fuel Obligation (RTFO), a mechanism introduced by the Department for Transport (DfT) in 2008 to encourage the production and use of biofuels – including BioSNG – in the transport industry.

Under the RTFO suppliers of transport and non-road mobile machinery fuel[39] in the UK must source a percentage of the fuel they supply from renewable and sustainable sources, including BioSNG, creating demand for these fuels.[40]

The obligation for each obligated supplier is calculated as the total volume of fuel supplied less the volume of sustainable fuel, hence the obligation is calculated from the volume of fossil fuel and renewable fuel that does not meet the sustainability criteria. This total is then multiplied by the obligation percentage for that period, which is the target percentage of renewable and sustainable to be fuel supplied set by government. The obligation percentage is currently 4.987%, which translates to 4.75% renewable supply when double counting and carry over has been removed.[41]

Obligated suppliers comply with the RTFO by redeeming Renewable Transport Fuel Certificates (RTFCs), which can be claimed by supplying sustainable renewable fuels, or by paying a fixed sum for each litre of fuel for which they wish to 'buy-out' of their obligation.

The price of an RTFC is set by the market for the certificates, however the buy-out price of 30 pence per RTFC represents the upper limit.[42] Suppliers of sustainable renewable fuels receive the price of the RTFC in addition to revenue from the sale of the fuel.

In general, one RTFC can be claimed for every litre of sustainable renewable fuel supplied. However, biogas attracts 1.9 RTFCs per kilogram of biomethane supplied, while fuel from feedstocks which are classed as a waste or residue is incentivised by awarding double the RTFCs per litre or kilogram supplied.[43]

Recently the government announced future development of the RTFO, including increasing the obligation level, i.e., the percentage of renewable supply (excluding double counting and carry over) to 9.75% in 2020, and 12.4% by 2032. In addition, a sub-target specifically for a small list of ‘development fuels’ will be introduced and set at 0.2% in 2019, rising to 2.8% in 2032. The increase in the development fuels sub-target is the driver of the increase in the overall obligation level from 2020 to 2032. BioSNG is considered as a development fuel, and therefore use of BioSNG for transport fuel will count towards compliance with the development fuel sub-target.[44]

[39] The obligation falls on suppliers that supply over 450,00 litres of fuel for transport a year, and only applies to supplies over that threshold (if total annual supply is less than 10mn litres)
[40] DfT (2012), Renewable Transport Fuel Obligation https://www.gov.uk/guidance/renewable-transport-fuels-obligation
[41] DfT (2017), RTFO Guidance Part One Process Guidance RTFO Year 10 15 April 2017 to 14 April 2018 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/604591/rtfo-guidance-part-1-process-guidance-year-10.pdf
[42] DfT (2017), RTFO Guidance Part One Process Guidance RTFO Year 10 15 April 2017 to 14 April 2018 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/604591/rtfo-guidance-part-1-process-guidance-year-10.pdf
[43] DfT (2017), RTFO Guidance Part One Process Guidance RTFO Year 10 15 April 2017 to 14 April 2018 https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/604591/rtfo-guidance-part-1-process-guidance-year-10.pdf
[44] DfT (2017), The Renewable Transport Fuel Obligations Order Government response to the consultation on amendments https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/644843/renewable-transport-fuel-obligations-order-government-response-to-consultations-on-amendments.pdf

3.3.2 Option B2: A variable top-up payment linked to the market price of gas

The success of a fixed 'top up' payment of the kind described above would also depend, to a degree, on the outlook for natural gas prices, revenues from gate fees and the difference in costs between BioSNG and natural gas producers: if the natural gas price was to fall too far, a fixed 'top up' payment may not be sufficient to cover the additional costs of the BioSNG producers. Equally, if the price of natural gas increased sufficiently, the 'top up' payments may not be required by BioSNG producers and may no longer represent good value-for-money for gas bill payers.

An alternative approach might, therefore, be to link the 'top up' payment to the difference between (i) the fixed price that a BioSNG plant would require in order to be commercially viable; and (ii) the market price of natural gas (which varies over time).[45]

Specifically, BioSNG developers could apply for long-term CfDs for low carbon gas, whereby producers would be paid the difference between a strike price, and the wholesale gas market reference price (which would be the price that BioSNG plant operators could sell the gas they produce at), for each unit of low carbon gas they produced, for a set period of time. The strike price would be set at the estimated total cost of the low carbon gas plant for development, construction, and the period of operation covered by the CfD (net of expected gate fees). The strike price could be set administratively by government or it could be determined by an auction (where BioSNG producers would bid the strike price they require). The strike price could be differentiated for the different technologies used in the production of low carbon gas, accounting for the differences in financing, construction and operational costs.

These arrangements could operate in a similar way to the CfD mechanism already in place in electricity markets, as explained in Case Study 3 below.

The effectiveness of this potential support mechanism will be dependent on whether low carbon gas plant owners can achieve the market reference price used in the mechanism, as that is the basis of the calculation for the level of support from the mechanism, which contributes to total revenue received.

[45] We have assumed that natural gas will continue to be the marginal source of gas in the GB gas market and, therefore, the determinant of the market price of gas and that BioSNG, other green gases and natural gas will all be substitutable and therefore part of one single gas market.

Case Study 3: Contracts for Difference in the wholesale electricity market

The government introduced a Feed in Tariff with CfD (CfD) support mechanism for large low carbon electricity generation projects as part of the Electricity Market Reform package, with the CfDs being awarded to planned future projects in 2015.

The government chose the CfD as the lead option[46] to support decarbonisation of the electricity sector as they concluded that it provided the best balance between achieving decarbonisation, security of supply and affordability objectives. Specifically, the CfD provided resilience to low gas prices, incentivised efficient dispatch through exposure to the gas market price, and enabled lower costs of capital through price certainty.[47]

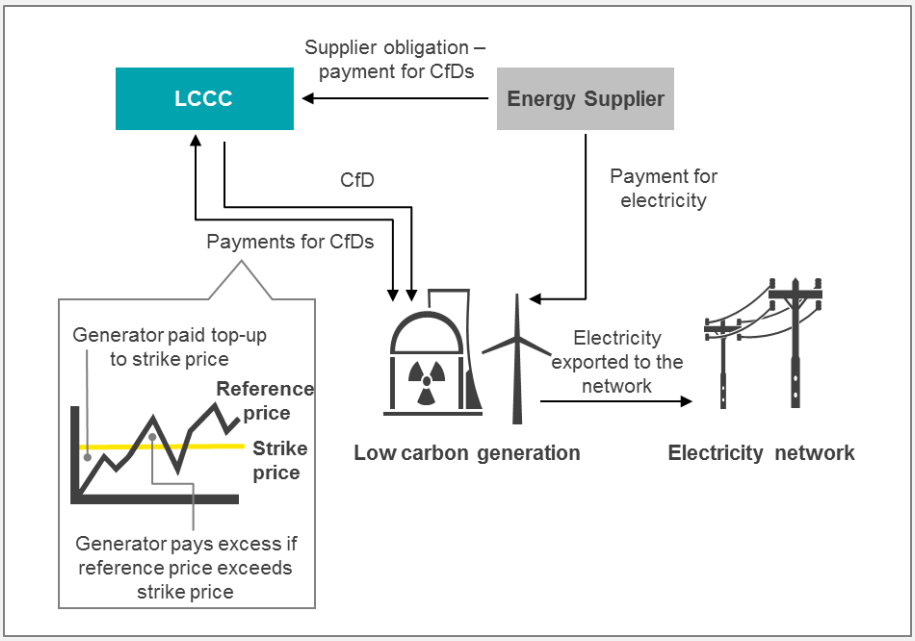
CfDs for large low carbon generation are private law contracts between the generator and the Low Carbon Contracts Company (LCCC) (a government owned company set up to act as a counterparty to the CfD contracts). The LCCC pays the generator the difference between a 'strike price' and the wholesale electricity market reference price when the reference price is below the strike price, and vice versa, providing the generator with price certainty.[48] The CfD has a 15 year contract length, from payment start date, for renewable generation.

The strike price is specific to the low carbon generation technology, reflecting the expected financing, construction, and operating costs of the plant. The strike price is set in different ways for different technologies, depending on technology maturity and the level of competition among developers. For example, it is administratively set by government for less established technologies such as geothermal technologies, negotiated bi-laterally with government in the case of nuclear, or by competitive auction in the case of offshore wind.

The cost of the CfDs are levied on suppliers, through the 'supplier obligation', and are recouped from suppliers' customers through retail electricity tariffs. The supplier obligation is collected by the LCCC.[49]

These arrangements are illustrated in Figure 3 below.

Figure 3: Stylised electricity and payment flows for CfDs



To date, eight major renewable electricity projects, totalling 4.5GW, were awarded Investment Contracts (early CfDs),[50] the 3.2GW Hinkley Point C nuclear plant was awarded a CfD via bilateral negotiation,[51] and 5.4GW of low carbon generation has been awarded a CfD in the first two CfD auctions.[52]

3.3.3 Option B3: Fixed top-up payments for low carbon gas production capacity

The 'top up' payment mechanisms described above have linked those payments to the amount of gas produced by the plant. This still leaves investors exposed to movements in gas markets (which impact on the amount of revenue the BioSNG plant can earn and therefore how much gas the plant might produce) and to fluctuations in the demand for BioSNG (which, among other factors, may depend on other government policies, e.g., the electrification of heat or roll out of heat networks). Investors might therefore, in some circumstances, prefer payments to be linked to the existence of the BioSNG plant, e.g., its availability to produce, or its capacity to produce, gas, rather than the amount of gas it actually produces.

In this case, in its simplest form, developers of BioSNG plants could apply for a stream of payments from government per unit of production capacity over some fixed period of time, e.g., the expected life of the plant. The payments could be set by competitive auction or determined by government. Successful bidders would receive a capacity award and payments for the duration of the award as long as they were available to produce gas for a predetermined proportion of the year. Capacity payments would be recovered from gas suppliers in proportion to their customers' gas demand through a levy, the cost of which would be passed on to gas customers.

The above description envisages government determining the value of capacity based on an assessment of the costs of BioSNG and potential market revenues (including gate fees). This would introduce the risk of government over or under-estimating those costs and revenues, so an alternative approach might be for the capacity payments to be determined by an auction, with government setting a target capacity and project developers submitting bids based on their own views of BioSNG costs and revenues. In this case, the payment would be set by the price that cleared in the market, similar to the way that capacity auctions currently operate in the electricity sector (as described in Case Study 4 below).

[46] The CfD was the lead option in terms of both a) its precise design, i.e. a FiT with a CfD, was considered to provide better value for money than a fixed FiT or a FiT with a fixed premium; and b) it was the lead option out of the three reforms implemented to support decarbonisation, namely the carbon price support mechanism, the CfD, and the Emissions Performance Standard.
[47] DECC (2010), Electricity Market Reform Consultation Document https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42636/1041-electricity-market-reform-condoc.pdf
[48] BEIS, Contracts for Difference https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference
[49] BEIS (2015), Electricity Market Reform: CFD Supplier Obligation https://www.gov.uk/government/collections/electricity-market-reform-cfd-supplier-obligation
[50] DECC (2014), Final Investment Decision (FID) Enabling for Renewables – Investment Contracts https://www.gov.uk/government/publications/final-investment-decision-fid-enabling-for-renewables-investment-contracts
[51] BEIS (207), Hinkley Point C https://www.gov.uk/government/collections/hinkley-point-c
[52] BEIS (2017), Contracts for Difference https://www.gov.uk/government/publications/contracts-for-difference/contract-for-difference

Case Study 4: Capacity payments in the electricity sector

A market for electricity generation capacity was established by the government to ensure that there is sufficient investment in reliable capacity to provide security of supply, as part of the electricity market reform.

The capacity market for electricity generation was designed as a competitive auction process run four years ahead of delivery for new capacity (i.e., yet to be built), and one year ahead of delivery for existing capacity. The auctions use a descending clock format, i.e., the price offered is reduced until the minimum price is reached at which the supply of capacity offered by bidders is equal to the target volume of capacity.[53]

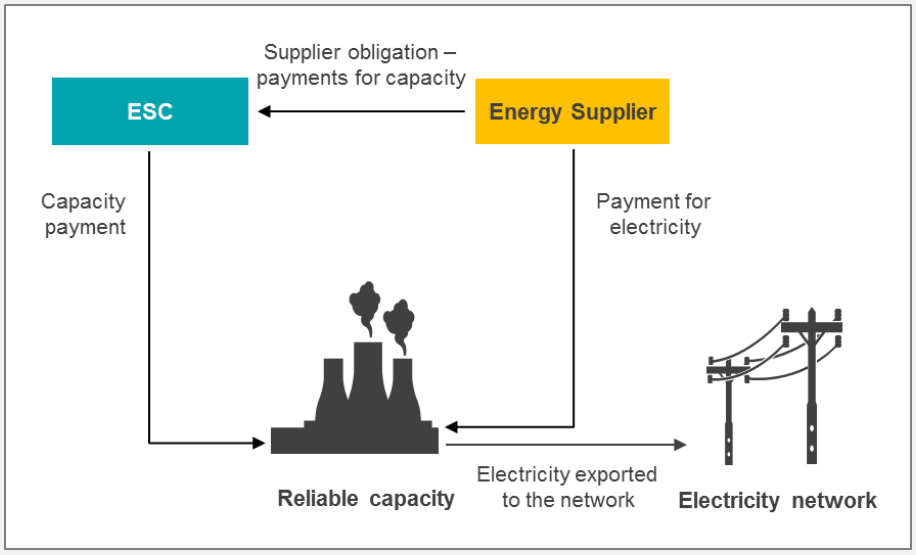
Successful bidders are awarded 'capacity agreements', which provide monthly payments for capacity in return for a commitment to be available and deliver energy when required at times of high demand in the delivery year(s), or face a penalty. The capacity payment, which is fixed per unit of available capacity, is equal to the clearing price set by the marginal bidder, i.e., the auction is 'pay-as-clear', and is fixed for the duration of the capacity agreement.[54] Capacity agreements can last fifteen years for planned new capacity and three years for existing capacity in the capacity auction held four years in advance of delivery, with payments linked to inflation. Auctions held one year in advance of delivery offer one year capacity agreements.

Payments received by capacity owners are additional to any payments they may receive for generating electricity. As the capacity market is competitive it incentivises capacity owners to bid into the auction at a level which covers their costs, less the revenues they expect to earn from the sale of electricity.

Similarly to CfDs, the cost of the capacity payments to generators are levied on suppliers (known as the Capacity Market Supplier charge), and are recouped from suppliers' customers through retail electricity tariffs. The Capacity Market Supplier charge is collected by the Electricity Settlements Company (ESC), a government owned company established specifically for this purpose. The ESC is also the generators' counterparty, responsible for paying the generators for the capacity they have provided.

These arrangements are illustrated in Figure 4 below.

Figure 4: Stylised electricity and payment flows for the Capacity Market



The fourth main Capacity Market auction was successfully concluded in February 2018 (for delivery in 2021/22), securing 50.4GW of capacity.[55]

[53] Target capacity for the relevant Delivery Year is set by BEIS, with reference to National Grid's Electricity Capacity Report

3.3.4 Option B4: Higher gate fees for acceptance of waste from Local Authorities

All of the 'top up' payment mechanisms described so far in this section have focused on increasing revenue that is sourced from gas consumers, via gas suppliers. The other key revenue stream for a BioSNG plant is from gate fees charged to parties seeking to dispose of household waste.

An obligation on local governments could be developed to send a set proportion of non-reusable household waste to be converted into green gas, by using technologies such as BioSNG.

The BioSNG plant would convert the waste into gas, which would then be sold onto a gas shipper or supplier, at the market price for gas. This would still be one of the BioSNG plant's revenue streams under this mechanism.

Local government would have to pay gate fees for the waste to be taken by the BioSNG plant, as is the case now, potentially under long-term contracts.[56] However, if the amount of household waste that had to be sent to BioSNG facilities exceeded the existing capacity of BioSNG plants which could convert waste into gas, then the gate fees that BioSNG plants could charge would increase. To the extent that these gate fees would exceed the level that would have applied in the absence of the obligation, these additional revenues can be thought of as similar to a 'top up' payment. Moreover, as these gate fees could be the subject of a multi-year contractual agreement, the 'top up' payments can be thought of as similar to fixed payments.

By increasing revenues from gate fees, the BioSNG plants may be able to sell gas to shippers and suppliers at a more competitive price (potentially increasing revenues from sales of gas as a result). BioSNG developers would, however, continue to be exposed to movements in market prices of gas under this set of arrangements.

Over time, the ready supply of household waste and revenue from gate fees may stimulate further investment in BioSNG technology, which – as the imbalance between supply of household waste and BioSNG plant capacity is addressed – may lead to some reduction in the gate fees that BioSNG plants are able to achieve. To the extent that this increase in capacity was accompanied by a reduction in BioSNG plant costs (e.g., as the technology matures), the reduction in revenues from gate fees may not need to be offset by higher revenues from sales of gas to shippers and suppliers.

3.4 Option C1: Guaranteed offtake arrangements

Each of the different sets of arrangements described above leaves BioSNG investors exposed to some kind of merchant risk: changes in market prices of gas, revenues from gate fees, the demand for gas, the costs of the plant (either financing, capex or opex) or to the underlying technology risk (which would influence the availability of the plant's capacity to produce gas when required). To the extent that those risks could not be minimised sufficiently, through the mechanisms above, investors may require even greater certainty over their expected revenues in order to proceed with developing a BioSNG plant.

[54] DECC (2014), Implementing Electricity Market Reform (EMR) https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/324176/Implementing_Electricity_Market_Reform.pdf

[55] National Grid (2018), Provisional Auction Results T-4 Capacity Market Auction 2021/22 https://www.emrdeliverybody.com/Capacity%20Markets%20Document%20Library/Provisional%20T-4%20Results%20DY%202021-22.pdf

[56] There may be other ways that a Local Authority could contribute to supporting BioSNG investments. For example, a Local Authority could form a joint venture with other co-investors to develop BioSNG plants in order to dispose of residual household waste from their local area. Local Authorities could also consider participating in this kind of scheme as part of supplying local energy to local residents, similar to developments seen recently in the gas and electricity supply sectors where a number of Local Authorities have established their own local energy companies, e.g., Bristol Energy and Robin Hood Energy.

Another option for stimulating investment in BioSNG might, therefore, be for government to act as – or require another party to act as – a guaranteed off-taker that would pay the BioSNG plant a fixed stream of revenues regardless of production or availability for production. Such arrangements would further insulate the BioSNG investors against demand and technology risks, by guaranteeing their revenues regardless of whether the plant produces any gas and whether there is any demand for that gas in the market-place. These risks would effectively be transferred to the off-taker, who would be out-of-pocket if the plant did not produce any gas or if they were unable to on-sell the gas to end-consumers.

One way these arrangements could work is to require gas suppliers to pay the BioSNG plant a contractually-specified amount of money (with variation in opex for volume of BioSNG produced) for a set number of years, regardless of the actual production of the plant.[57] The revenue stream would be set at a level sufficient to cover the development, construction, and operational[58] costs of a plant (net of gate fees), and vary across technology types, in order to provide price certainty for the duration of the contract.

The supplier would need to pass on the costs incurred under the contract with the BioSNG producer to end-customers. To the extent that the gas produced by the plant could be substituted for natural gas, the suppliers' costs of purchasing natural gas would be reduced, but overall costs would be expected to rise if the BioSNG plant was more expensive (per unit produced) than the alternatives.

The costs of this mechanism incurred by gas suppliers would be in proportion to their customers' gas demand compared to total GB gas demand. Therefore at the end of each year, gas suppliers will submit documentation on the total cost of the fixed tariffs for low carbon gas production that they have incurred to Ofgem, and Ofgem will oversee a reallocation of funds amongst gas supplier when necessary. Gas suppliers would recover the cost of the mechanism from their customers through retail gas tariffs.

It is worth noting that while these guaranteed offtake arrangements protect BioSNG investors against revenue risks, the investors continue to be exposed to construction, financing and operational risks: if these costs turn out to be higher than expected – as reflected in the stream of revenues guaranteed under the offtake agreement – the rate of return achieved by the BioSNG investor will be lower than expected. The reverse is also true, so the contractual offtake agreement should incentivise investors to bring forward projects unless the probability distribution of these risks is not symmetrical or if significant aspects of these risks are outside of investors' control, e.g., dependent on technology developed by third parties.

The contractual arrangements could include provisions to enable the stream of revenues to be adjusted in certain circumstances to help protect investors against some of the financing, construction and operational risks identified above, but careful consideration would have to be given to whether this represented value-for-money for customers: the more that investors are insulated from these risks, the less incentive they will have to mitigate them in the first place, potentially leading to a higher overall cost for gas bill payers.

These arrangements would have some similarities to the Feed in Tariffs already applied to certain electricity generation technologies (as described in Case Study 5 below), though the arrangements described arguably go further by protecting the BioSNG investor against any underlying technology risk (which might prevent the plant from producing low carbon gas that could be used in the market). Recognising that this option removes a lot of risk from BioSNG investors and developers, this may not be an appealing option to government.

[57] This assumes that gas suppliers are regarded as sufficiently creditworthy counterparties to the offtake agreement. An alternative could be for the government to act as the counterparty itself e.g. via an entity similar to the LCCC.
[58] For the period of the contract.

Case Study 5: a Feed-in-Tariff for renewables and micro CHP

A Feed-in-Tariffs (FITs) scheme was established by the government in 2010 to encourage and promote use of renewable and low-carbon electricity generation technologies.[59]

Under the FITs scheme, a contract is established between the installer of either a renewable generation technology, or a micro-Combined Heat and Power (CHP) plant, and an electricity supplier for 20 years (10 years for micro-CHP plants). Electricity suppliers with over 250,000 domestic customer accounts are required to offer FIT contracts.

Fixed tariff payments are made on a quarterly basis by the electricity supplier to the installer for the low-carbon electricity they generate, and for the low-carbon electricity they export to the network. The fixed tariff payment rates are set by the Department for Business, Energy and Industrial Strategy (BEIS) and adjusted annually, in line with Retail Price Index (RPI) inflation. The fixed tariff payment received for the duration of the contract means the renewable generation technology or micro CHP plant is not exposed to the prices in the electricity market for the power they generate.[60]

The FIT Levelisation Fund is used to spread the cost of FITs across all electricity suppliers (regardless of whether they are required to offer FIT contracts) in line with their market share; these costs are then passed onto the electricity suppliers' customers through retail electricity tariffs.

The number of new installations that can receive support under the FIT scheme is limited by a deployment cap.[61]

3.5 Regulated business models

The guaranteed offtake arrangements described earlier essentially operate through a contract between the gas supplier and the BioSNG producer. These contractual arrangements would be attended by some risks: in particular, the risk that the counterparty (the supplier) is unable to meet its obligations to the BioSNG plant, a risk which might lead to the BioSNG plant's cost of capital being higher than it otherwise might be and to the gas supplier levying higher prices to end-customers to compensate for the additional risks that it would bear under those arrangements.

An alternative way to provide a similar level of support to BioSNG could be to appoint and licence specific parties to construct, finance and operate the assets and to apply economic regulation to protect customers against overpaying for those investments. As in the contract model described in Section 3.4, these regulatory models would pre-suppose that the BioSNG investments were required and pass on the risk to end customers that BioSNG turned out not to be cost competitive and/or capable of being used to supply customers, i.e., end-customers, via their energy bills, would pay for the BioSNG investments whether the gas they produced was ultimately used or not.

Depending on the design of the regulatory models, these arrangements may also afford more flexibility to allocate or mitigate financing, construction and operational risks than contractual models, e.g., while contractual models could, theoretically, enable the revenue stream or tariffs to be updated in pre-determined circumstances, unless the contract could anticipate all of the possible circumstances which might arise and a court or arbitrator could adjudicate on any disputes in a timely manner, there may be some advantages in enabling a trusted, independent third party – the economic regulator – to address these issues through the exercise of its judgement within the constraints of the BioSNG plant's licence and any other relevant statutory provisions. This could include periodically resetting the allowed revenues to take account of updated information in some cases, or allowing the revenue stream to be re-set after the construction phase (to reflect actual capex costs). Of course, offering more

[59] Ofgem, Feed-in Tariffs www.ofgem.gov,uk/environmental-programmes/fit/about-fit-scheme
[60] Ofgem, Feed-in Tariffs www.ofgem.gov,uk/environmental-programmes/fit/fit-tariff-rates
[61] Ofgem, Feed-in Tariffs www.ofgem.gov,uk/environmental-programmes/fit/about-fit-scheme

discretion to the economic regulator also increases regulatory risk, which would need to be carefully balanced against any perceived benefits of such a model.

There are a range of models of economic regulation, but three of the models which are applied to energy infrastructure in the UK include:

- A fixed long-term regulated revenue stream, determined at either the initiation of the project or at the end of the construction phase;
- A long-term regulated revenue stream, subject to a cap and floor; and
- A long term regulated revenue stream, subject to periodic reset by an independent economic regulator.

3.5.1 Option D1: A fixed long-term regulated revenue stream

A fixed long-term regulated revenue stream could be established in a number of ways. One way would be similar to a concession model, whereby the revenues were set in advance for the duration of the concession agreement and the concessionaire (in this case the BioSNG developer) would then be entitled to collect those revenues, subject to meeting any performance targets specified in the agreement. In this case the revenues would be set in advance based on the expected costs of the concessionaire.

An alternative way to provide a fixed long-term regulated revenue stream would be to auction off the license and entitlement to the revenue stream to independent third party bidders via a competitive auction. This model would have some similarities to the Offshore Transmission Owner (OFTO) or Competitively Appointed Transmission Owner (CATO) regulatory frameworks that Ofgem has developed, as discussed further below in Case Study 6.

If similar arrangements were applied to low carbon gas plant, including BioSNG plants, then potential developers of these projects would be invited to compete for the licence to construct, finance and operate a given plant with particular specifications (e.g., capacity) at a particular location determined by Ofgem, the System Operator (SO) or another appropriate third party. The bids submitted by the developers would include forecast costs, forecast gate fees, and the required revenue stream, which would be key inputs to the decision as to who to award the licence to.

The winning bidder for each BioSNG plant licence would be awarded a long-term guaranteed revenue stream sufficient to cover the expected construction and financing costs of the plant. Arrangements could be included to ensure that the licence holder faced strong incentives to deliver on its commitments, e.g., financial penalties if the plant was not operational for a prolonged period of time.

An alternative approach to identifying BioSNG investments could be to open ‘bid windows’, during which potential developers could submit their plans to Ofgem, the SO or relevant third party for evaluation. If the plans were assessed to meet certain pre-specified criteria, the revenue stream (or the process for calculating it) that would be made available to the developer could be set out and the developer could proceed with the project if they found that revenue stream acceptable. The revenue stream could be based on the forecast costs submitted by the developer as part of their application. Such an approach would have some similarities to the way that Ofgem currently invites developers to submit bids for potential electricity interconnector projects. The ability for developers to design their own projects may allow for more innovation at this stage of the project life cycle and may lead to lower overall costs, but may come at the cost of some competitive tension amongst bidders (though the ‘bid window’ approach does mean that Ofgem can have several bids to evaluate and compare at the same time).

In either case, the gas produced by the BioSNG plant could be sold to the market and the market revenues offset against the regulated revenue stream. Customers would then only have to top up the revenue stream if market revenues were insufficient to fund the full

regulated revenue stream. A mechanism would need to be included within the licence awarded to the BioSNG plant to address the situation where market revenues from the sales of gas exceeded the allowed regulated revenue stream. This mechanism could share the additional revenues between BioSNG investors and gas bill payers in some way.

Case Study 6: Offshore Transmission Owner and Competitively Appointed Transmission Owner models

In 2009, government and Ofgem established a bespoke regulatory regime for offshore electricity transmission assets (i.e., subsea cables and associated substations, etc.), referred to as the Offshore Transmission Regime. Its introduction was motivated by the need for investment in offshore transmission to connect offshore wind farms, and Ofgem's belief that introducing more competition into this part of the sector might lead to better value for money for end-customers.

Under the Offshore Transmission Regime bidders compete for Offshore Transmission Owner (OFTO) licences to operate the new offshore transmission assets, with 20 year inflation-linked revenue terms.[62] The projects are constructed by an offshore windfarm developer – whose windfarm is connected to the OFTO asset – and then transferred to the auction winner post-construction.

The first four OFTO tender rounds resulted in 15 operational OFTOs with £2.9bn of investment.[63]

In the future, a similar regime may be available for large, new and separable onshore electricity infrastructure. Under the Competitively Appointed Transmission Owners (CATO) regime, electricity transmission owners and/or the System Operator would identify appropriate investment opportunities in the onshore electricity transmission assets, and run a tendering process for the design, build, and operation of the selected asset. The CATO regime requires the introduction of legislation, which, as yet, has not been tabled in Parliament,[64] but Ofgem is also considering whether a similar outcome can be achieved by requiring the onshore gas and electricity networks to run competitive tendering processes for selected assets as part of its RIIO-2 price control review (an approach that may not require new legislation to be passed to enable it to be implemented).

3.5.2 Option D2: A fixed long-term cap and floor regulated revenue stream

One potential drawback of the approach above is that customers pay for the BioSNG plant, regardless of whether it produces any BioSNG and whether that gas is actually consumed or not. One way of retaining some of the protections against financing, construction, operational and technology risks that a regulated model may be able to deliver, but ensuring that investors are incentivised to maximise market revenues, could be to adopt a 'cap and floor' approach.[65] Under this model, the single fixed revenue stream described above would be replaced with a pre-determined minimum and maximum revenue which the BioSNG project would be entitled to recover from sales of BioSNG into the gas market and via gate fees for the disposal of household waste.

In this case, BioSNG plant developers would apply to Ofgem to build a plant under a revenue cap and floor regime. If Ofgem were satisfied that the new BioSNG plant would be in consumers' interests, a cap and floor arrangement could be awarded. The owners of the BioSNG plant would sell the BioSNG and seek to maximise gate fees in the same manner as under a commercial model. A revenue cap and floor for a BioSNG plant could be established by considering what revenues would be needed to make the plant financeable, with the range

[62] Ofgem, Offshore transmission https://www.ofgem.gov.uk/electricity/transmission-networks/offshore-transmission
[63] Ofgem (2016), OFTO Tender Round 5 https://www.ofgem.gov.uk/ofgem-publications/104325
[64] Ofgem, Competition in onshore transmission https://www.ofgem.gov.uk/electricity/transmission-networks/competition-onshore-transmission
[65] While BioSNG investors would be primarily interested in a guaranteed minimum rate of return underwritten by end-consumers to help de-risk the investment, in practice Ofgem might seek to impose a ceiling on the allowed rate of return to protect customers as a quid pro quo for the guaranteed floor.

between the cap and floor representing the uncertainty in costs, and taking account of what Ofgem considers to be an appropriate range for rate of return. If revenues fell below the floor, the difference could be made up through a charge on gas suppliers, the costs of which would be passed on to end gas consumers. The opposite would be true if revenues rose above the cap.

Adopting this type of model would only be possible if there was a reasonable prospect that investors could earn commercial revenues between the cap and floor levels: if the expected market revenues were significantly below the level required to make the project financeable (which is where the floor rate of return might be set), then investors would be unlikely to bring forward potential projects as the floor rate of return would be insufficient to attract equity investment. A cap and floor model might, therefore, work best where a market for BioSNG had been established and was potentially viable, but there was significant uncertainty around the outlook for that market that made it challenging for project developers to attract the necessary capital investment.

Case Study 7: Electricity interconnectors

Recognising that private sector developers were finding it difficult to attract finance for electricity interconnectors fully exposed to market risks, Ofgem introduced the cap and floor regulatory regime for new electricity interconnectors in 2014 to provide increased certainty for investors about the revenues which the interconnector could earn.

Under the cap and floor regime developers apply to Ofgem to build, finance and operate an interconnector, and the applications are assessed on whether it is in the consumers' interest, which includes an assessment of the level of efficient costs. If the project is expected to benefit consumers, a cap and floor arrangement is granted.

Interconnector owners primarily earn revenue from selling capacity of their interconnector allowing electricity to flow. The levels of the revenue cap and floor are set in advance for 25 years, and indexed to inflation. However, the cap and floor is also subject to an availability incentive and can be adjusted if a pre-specified event occurs, e.g., force majeure.

The floor is based on the cost of debt using a benchmark of yields on A and BBB rated debt, and the cap based on a benchmark cost of equity applicable to a generator. If revenues fall below the floor, the System Operator pays the interconnector owner to make up the difference, and this cost is eventually passed on to electricity consumers. The reverse also applies.[66] In general, revenues are assessed against the cap and floor every five years in order to determine if additional payments should be made to the interconnector (or if the interconnector needs to return money to customers).

There are six interconnectors, totalling 6.7GW, that are expected to become operational under the cap and floor regime in the future.[67]

3.5.3 Option D3: A long term regulated revenue stream, subject to periodic reset by an independent economic regulator

An alternative, or a complement, to third parties bringing forward BioSNG projects for regulated revenue streams, could be to allow the existing GDNs to develop BioSNG projects and incorporate the expenditure into their existing RIIO price controls. This option represents a fundamental change to the role and regulation of a GDN, however is somewhat in line with Professor Dieter Helm's proposal (albeit for the electricity sector) to remove the distinction

[66] Ofgem (2014), Decision to roll out a cap and floor regime to near-term electricity interconnectors https://www.ofgem.gov.uk/publications-and-updates/decision-roll-out-cap-and-floor-regime-near-term-electricity-interconnectors

[67] Ofgem, Electricity Interconnectors https://www.ofgem.gov.uk/electricity/transmission-networks/electricity-interconnectors

between different types of licences, and have a single licence for distribution, generation and supply activities.[68]

In this case, the GDNs would be permitted under RIIO to spend money on increasing the amount of low carbon gas, including BioSNG, that is transported along their network and/or used as shrinkage gas.[69] The money could be used to fund expenditures related to the production and transportation of low carbon gas and could be subject to the same regulatory regime as other expenditures, i.e., a proportion of the expenditure would be added to the Regulatory Asset Value (RAV) and depreciated over time with the remainder recovered in the year it is incurred. The regulatory depreciation period set for BioSNG investments could be set equal to the same assumptions used for other investments by GDNs, or it could be set on a bespoke basis with regard to balancing the impact on the cost of capital, the impact on consumer bills, and the distributional impact across generations of consumers.

By incorporating the funding of BioSNG into the price control framework and the GDNs' allowed revenues, it would be recovered from customers as part of their gas bills, regardless of the actual amount of BioSNG produced, transported or consumed (subject to any targets and incentives that Ofgem may set within the price control for BioSNG production or the availability of the plant). So long as the RAV continued to be protected by Ofgem, no asset stranding risks would arise, and BioSNG investors would be guaranteed to recover their investment and to earn a return on the capital invested, providing performance targets are met.

The existing arrangements embedded in the RIIO framework for allocating financing, construction and operational cost risks would apply equally to the BioSNG investments, meaning that a proportion of any over-spends would be borne by investors (and a share of underspends passed back to consumers). The rate of return allowed on the BioSNG investments would be determined by Ofgem and could be set equal to the weighted average cost of capital applied to GDNs' RAV.

The BioSNG gas produced could be sold to the market and those revenues offset against the allowed regulated revenues. Arrangements would need to be put in place to address the situation where the market revenues fall short of, or exceed, the allowed regulated revenues for the BioSNG plants. Consideration would need to be given to whether a single or dual till approach should be taken and how to share the higher or lower revenues between investors and customers.

Enabling GDNs to determine when and where to invest in BioSNG might avoid some of the additional costs associated with administering competitive auctions or bid windows (discussed above) and could take advantage of GDNs' knowledge of the best places to site these investments on their networks, but would need to be weighed against any potential cost savings that might arise from allowing third parties to design, finance, construct and operate their own projects.

GDNs could be required to sell off their BioSNG investments within a specified time period to promote competition in the market for BioSNG as the market matures. In this case, to ensure that GDNs are appropriately incentivised to invest in BioSNG and build long term viable projects, it may be appropriate that GDNs are able to retain (bear) a share of any profits (losses) made on the sale.

[68] Helm (2017), Cost of Energy Review https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/654902/Cost_of_Energy_Review.pdf

[69] Energy network companies in GB are subject to economic regulation by Ofgem; the current regulatory regime is known as RIIO and runs from 2013-21 for gas transmission and distribution networks. At the beginning of each price control the energy networks submit a business plan setting out, and justifying, their activities and expenditure over the forthcoming price control period. Following a period of consultation, Ofgem determines the allowed total expenditure (capex and opex combined) for the energy network companies for the price control period. For further details, see Ofgem, Network price controls https://www.ofgem.gov.uk/gas/distribution-networks/network-price-controls Energy network's allowed expenditure is funded through the tariffs paid by gas shippers and energy suppliers, and these tariffs are in turn passed on to energy consumers.

3.6 Summary

In this section we have outlined several different options which may be available to policy makers and/or the economic regulator to stimulate investment in BioSNG (if that is determined to be appropriate). These options, which are a sample across a range of possibilities and not an exhaustive list, are summarised in Table 5 below.

Each of the options allocates risk in different ways and may have different implications for different sets of stakeholders: there are advantages and disadvantages to each of these options. Accordingly, in the following section we evaluate the options against stakeholder objectives and identify a small number of options for policy makers and other interested stakeholders to consider further (if it is decided to try and stimulate investment in BioSNG).

Table 5: List of potential mechanisms to stimulate investment in BioSNG

Option	Description
A. Government support	
A1	**Government guarantee of project debt:** Government provides guarantees of private sector loans to BioSNG projects, making it easier for projects to attract debt and equity investment. The costs of support are borne by taxpayers.
A2	**Government grant:** Government provides a financial grant at the outset of the project, making it easier to attract debt and equity investment. The costs of support are borne by taxpayers.
B. 'Top-up' payments	
B1	**Fixed premium to market price of gas:** Fixed top up payments to BioSNG projects for each unit of gas produced, over and above revenues from the sale of BioSNG produced. The top-up payment is calibrated to take into account expected revenues from gate fees. The payments are funded by gas suppliers, and passed on to gas consumers via their bills.
B2	**Variable top-up linked to market price of gas:** Variable top payments to BioSNG projects, on top of the market price of gas, to allow projects to earn a stable total price per unit of BioSNG produced. The top-up payment is calibrated to take into account expected revenues from gate fees. The payments are funded by gas suppliers, and passed on to gas consumers via their bills.
B3	**Fixed top-up for low carbon gas production capacity:** Payments to BioSNG projects for each unit of capacity available to produce BioSNG, in addition to any revenues earned for the sale of BioSNG produced and from gate fees. Payments are set via a competitive auction. The payments are funded by gas suppliers and ultimately passed on to gas consumers via their bills.
B4	**Higher gate fees for acceptance of waste from Local Authorities (LA):** LAs are obligated to send a proportion of household waste to BioSNG plants, and LAs pay gate fees for each unit of waste used to produce BioSNG. BioSNG projects also earn revenues from the sale of BioSNG produced. LAs will pay higher gate fees because demand for disposal of waste to BioSNG will be set at a higher level than the available capacity of BioSNG plants. The costs of support are borne by LA taxpayers.
C. Guaranteed offtake arrangements	
C1	**Guaranteed offtake arrangements:** Government or a third party enters into a contractual obligation to payments to a BioSNG project at a predetermined price per unit of BioSNG produced, regardless of the amount of produced. The payments are calibrated to recover the costs of the project and a fair rate of return for the risks borne. The payments are ultimately passed on to gas consumers via their bills.
D. Regulated Business Models	
D1	**Fixed long term regulated revenue stream:** BioSNG plants are a licensed and regulated activity, subject to a fixed long-term regulated revenue stream. The revenue stream could be determined by competitive auction and could be payable based on availability to produce BioSNG (rather than actual production). The payments are ultimately passed on to gas consumers via their bills.
D2	**Fixed long-term cap and floor regulated revenue stream:** BioSNG plants are a licensed and regulated activity, subject to a cap and floor on their revenues. The BioSNG project is guaranteed to earn a minimum level of revenue, but can potentially increase its revenues through high sales of BioSNG in the market and via high gate fees. The revenue stream could be determined by Ofgem after reviewing a business plan application from the project developer. The payments are ultimately passed on to gas consumers via their bills.
D3	**Long-term regulated revenue stream, subject to periodic reset:** BioSNG investments are undertaken by the Gas Distribution Networks (GDNs) as part of their existing regional monopoly regulated activities. The existing RIIO regulatory framework could be extended to cover these activities, potentially with some bespoke adjustments reflecting specific performance targets for BioSNG.

4. Evaluation of potential options for stimulating investment in BioSNG

The choice between the different options for supporting BioSNG outlined in the previous section ultimately depends on whether the given option delivers the objectives of the various stakeholders in BioSNG, such as:

- Customers and taxpayers, both current and future;
- Investors (both debt and equity) and developers; and
- Government (both national and local) and the regulator.

The objectives of these different groups are likely to be myriad and complex, and potentially inconsistent with each other, as Table 6 below summarises.

Table 6: Criteria for evaluating options to stimulate investment in BioSNG plants

Stakeholder	Potential objectives
All	► **Effectiveness** – the proposed support mechanism should enable efficient investment in BioSNG to come forward on a sufficient scale to enable decarbonisation of heat to play its expected role in the UK meeting its decarbonisation targets.
Customers and taxpayers	► **Value for money and competition** – the proposed support mechanism needs to encourage investment in BioSNG at the lowest overall cost (in present value terms), and BioSNG should only receive support if it can compete with other approaches. The duration of the intervention required, and the ability to close the support scheme down at some point in the future, may therefore be important. ► **Fairness** – the burden of paying for the cost of the support mechanism should fall on those who benefit from BioSNG and who are best able to afford the cost.
BioSNG investors and developers	► **Simplicity** – the proposed support mechanism should be simple to understand and administer. ► **Reasonable risk-adjusted returns** – the proposed support mechanism should enable investors (both debt and equity) to expect to earn a reasonable rate of return on their investment for the risks borne. ► **Revenue stability and predictability** – a mechanism which leads to more stable and predictable revenues may be preferable for investors (particularly debt investors). ► **Protection against asset stranding** – the proposed support mechanism should protect investors against asset stranding (including from political and/or regulatory risk). ► **Protection against unforeseen costs** – the proposed mechanism should provide an appropriate degree of protection against unforeseen cost shocks and/or costs not decreasing over time as quickly as expected.
Government (national and local) and regulator	► **Ease and pace of implementation** – a support mechanism that was easier and quicker to implement (e.g., did not require legislative change) might be preferred by government and regulators. ► **Innovation** – the support mechanism should encourage innovation in BioSNG, enabling technology costs to decrease and the ultimate removal of the support mechanism in the longer term. ► **Supply chain & industrial strategy** – a mechanism that supports development of a UK BioSNG supply chain might be preferred by government if it was believed that exports of this technology could be a valuable part of the UK's industrial strategy.

Note: some factors which may be important to stakeholders, such as timing of commitment, cost control, grandfathering, and land use issues, have not been included above as at this stage the options have not been developed to a sufficient level of detail to allow these points to be meaningful differentiators.

The criteria above reflect that there are trade-offs between the objectives of the different stakeholder groups and that careful judgements would need to be made. For example, the benefits of providing stronger support to BioSNG projects in the short term would need to be weighed against ensuring that appropriate incentives are in place to drive innovation and cost

reductions over the longer term, which in turn would be vital to securing net-benefits for domestic gas consumers and taxpayers (in present value terms) and stimulating a BioSNG export industry that might align with the UK's industrial strategy.

4.1 The strengths and weaknesses of the different options for stimulating investment in BioSNG

In this section, the performance of each of the options listed above (see Table 5) is evaluated against the criteria set out in Table 6 above.

Effectiveness

For the purposes of this report, all of the options considered are assumed to be equally effective at bringing forward investment in BioSNG and ultimately helping the UK to decarbonise gas. We make this assumption as otherwise we would not be carrying out an apples-with-apples comparison and implicitly we'd be assuming that the UK does not meet its 2050 climate change obligations. Each of the options considered would differ along the other key evaluation criteria, e.g., in terms of how much the support would cost, the value for money it would deliver and how easily it could be implemented. The options which decarbonise gas and perform best against all the other criteria would be expected to be the preferred options for stakeholders to consider further. The discussion below focuses on these dimensions.

Value for money

Which of the options will deliver the best value for money for stakeholders will depend on the specific commercial barriers to the deployment of BioSNG technology. Different options might be more appropriate in certain circumstances. For example:

- Options which allocate risks to stakeholders best placed to manage those risks are likely to lead to the best value for money outcomes overall;
- Options which transfer more risks onto customers and/or taxpayers – such as a fully regulated revenue stream or a fixed revenue stream linked to BioSNG gas production capacity (as opposed to output) – are more likely to bring forward investment in BioSNG, but greater care would have to be taken to ensure that these options represent value for money for customers and/or taxpayers;
- Options which expose investors to market forces will create the strongest incentives for investors to ensure that the projects are financed, constructed and operated as efficiently as possible. It would also incentivise investors to maximise revenues from gate fees and the gas market. This would be more likely to lead to innovation and efficiencies to be identified, reducing technology costs over time, leading to better overall value for money for customers/taxpayers;
- OPTIONS which increase the cost of gas bills would incentivise consumers to take action to reduce gas consumption (e.g., through measures such as increased insulation or installation of high efficiency boilers), which might lead to further or more rapid decarbonisation of the gas sector but which might also make it more difficult to recoup the costs of investment in the gas sector (including BioSNG) as sector costs would need to be recovered from a smaller pool of bill payers;
- some options might be more likely to give rise to potential unintended consequences given that they interact with or cut across mechanisms applying to different markets and sectors, e.g., by competing for the same bioenergy and/or methane or feedstocks;
- Due to information asymmetry between policy makers and regulators on the one hand and investors on the other, options which enable market forces and competition to be harnessed may be preferable to options that rely on policy makers and/or regulators trying to assess expected costs and revenues of BioSNG; and

- Options which allow for the level of financial support to be adjusted over time more easily, to take account of changes in technology costs (including unexpected decreases) or market revenues, reduce risks for consumers or taxpayers, but increase risk for project investors.

Detailed quantitative analysis of the value for money of different options is outside of the scope of work of this report. However, to illustrate the potential implications of the trade-off between the cost of capital for investing in BioSNG and the allocation of risks to different stakeholders, we note:

- The cost of capital may vary significantly between the different options considered in this report. For example:
  - The cost of capital for Options A1[70] – B4 might be proxied by the cost of capital of new investment in renewable heat which was estimated to be 12% (real, post-tax) by the Department of Energy and Climate Change (DECC) in 2011[71] and advisers to DECC estimated the cost of capital for new investment in energy from waste plant to be between 7.1-10.7% (real, pre-tax) in 2015;[72]
  - The cost of capital for funds contributed by taxpayers (e.g., via grants under Option A2 or the various payment streams under Options B1-B4 and C1) might be proxied by the social time preference rate used by HM Treasury for discounting public costs and benefits, i.e. 3.5% (real);[73] and
  - The cost of capital in Option D3 might be proxied by the cost of capital allowed for gas distribution networks by Ofgem at RIIO-GD1 for the 2013-21 period was 4.2% (real, vanilla)[74] or approximately 3.8% (real, post-tax) (although this figure has decreased slightly in recent years as the allowed cost of debt has been indexed to market interest rates).
- The duration over which support is provided may also vary significantly. For example:
  - Support under Options B1-B4 might be for a period of 15-25 years, reflecting the duration of support under existing Capacity Market and renewable support schemes;
  - Licences awarded under Options D1 or D2 might be for around 20-25 years, consistent with the OFTO and interconnector regimes; and
  - Asset lives might be assumed to be 45 years in Option D3, consistent with Ofgem's RIIO-GD1 regulatory framework for gas distribution networks.
- The cost of support from taxpayers and gas bill payers might therefore vary very significantly in net present value terms between the options. The exact calculations would depend on the upfront cost of investing in BioSNG and projected cash flows taking into account government support, market prices of gas, gate fees, financing costs and revenues from gate fees. However, it is clear that those options with the lowest cost of support in the short term would have the lowest costs of capital, but this is only achievable by transferring risks to taxpayers and bill payers that could reduce incentives

[70] We refer here to the private sector capital invested in these options, not the public sector capital invested via a grant under Option A2.
[71] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/48042/1381-renewable-heat-incentive-ia.pdf, page 11.
[72] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/566809/NERA_Hurdle_Rates_for_Electricity_Generation_Technologies.pdf, page vi. The hurdle rates estimated in this project were whole project rates i.e. at the project appraisal stage, reflecting all of the risks affecting Final Investment Decisions.
[73] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/220541/green_book_complete.pdf
[74] See https://www.ofgem.gov.uk/sites/default/files/docs/2012/12/1_riiogd1_fp_overview_dec12.pdf, p36.

to reduce costs over the longer term (leading to inferior value for money in present value terms).

The discussion above illustrates that different options may be worth considering further, i.e., no single option is obviously the solution in all cases. It might also be the case that different solutions are appropriate in different circumstances and a package of options might need to be deployed in order to deliver the best value for money for stakeholders.

Further investigation of the options, particularly detailed quantitative modelling of different options, may be appropriate at a later date to identify which option(s) should ultimately be adopted by government for stimulating investment in BioSNG. That modelling may need to recognise that there are multiple different ways that each of the options could be applied in practice and that further information about the characteristics – including risks – of investment in BioSNG will become available over time. Nevertheless, Options B2, B3 and D2 – which provide a degree of support to BioSNG but continue to expose projects to some commercial risks – might be expected to among the options which achieve the best overall value for money by stimulating investment in the short term and encouraging innovation and cost reductions over the longer term.

Table 7: Evaluation of options for stimulating investment in BioSNG – value for money

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Value for money (long-term)										

Key:

Fairness

The government guarantee (Option A1) and grant (Option A2) options would impose the costs of supporting BioSNG on taxpayers,[75] while higher gate fees (Option B4) would impose a higher share of the costs of supporting BioSNG on local authority taxpayers (who would ultimately pay the gate fees for disposal of residual household waste). By comparison, the other options would smear the costs across gas consumers (via their bills), though there would be differences in distributional and intergenerational equity (as discussed below).

Efficiency may be enhanced by requiring those who benefit (i.e., those who use the BioSNG) to pay for the scheme. This would suggest that recovering the costs through customer bills is fairer than recovering the costs through general or local taxation. However, the distributional and intergenerational implications of recouping the costs of supporting BioSNG via customer bills would depend on the exact mechanics of the arrangements and, potentially, on choices made by GDNs and gas suppliers about the structure of their tariffs.

For example recovering costs through customer bills could potentially be regressive if the same amount was added to all customers' bills to recover these costs, leading to less well off,

[75] In theory, it would be possible for a scheme to be designed to recover the costs of these options via gas bill payers, but for simplicity we assume that a grant or guarantee would be funded through general taxation.

including vulnerable/fuel-poor, customers paying a relatively greater share of the overall cost. However, if it is assumed that the tariff structures and charging methodologies currently in place appropriately distribute costs across the customer base (including appropriate discounts for vulnerable customers), then these distributional equity issues may be modest, particularly if the costs of supporting BioSNG are a small proportion of overall customer bills.

The different options have different implications for intergenerational equity as well since while all of the options would spread the costs of funding the support to BioSNG over time, they would not all spread those costs in the same way. Some options, such as fixed payments for capacity (which is likely to be stable over time) (Option B3), guaranteed offtake arrangements (Option C1) and fixed long term regulated revenue streams (Option D1) essentially annuitise the costs of the project over its lifetime, whereas the other options would profile costs over time in different ways. For example, if the costs were funded via a fully regulated revenue stream like the existing RIIO price controls applied to GDNs (Option D3), the investments would be depreciated using a sum of the digits approach spread over 45 years.

It would also be conceivable that different options would index revenues to inflation in different ways, e.g., the RIIO price controls (the basis for Option D3: long-term regulated revenue stream, subject to periodic reset) index 100% of revenue to changes in RPI inflation currently, but other types of regulated revenue stream (such as Option D1: fixed long-term regulated revenue stream) only link a proportion of revenues to RPI inflation and there are examples in other sectors where top up payments and guaranteed revenue streams are linked to CPI inflation.[76]

Combing the above, our overall assessment is:

- Options A1 and A2 score the lowest on this criterion because all the costs fall directly on the taxpayer rather than the gas user;
- Option B4 scores lower than most of the remaining options because a portion of the costs of the support scheme are borne by local authority taxpayers who do not necessarily proportionately benefit from the BioSNG produced;
- Option D3 scores lower than most of the remaining options because it spreads the costs of the investment in BioSNG over a longer period than the other options[77] (and we assume that this longer period exceeds the useful life of the BioSNG project, thereby deferring costs onto future customers who do not benefit from today's investment in BioSNG);
- Options B1, B2, B3, C1, D1, D2 and D3 score better than the other options as the costs of the support mechanisms are ultimately recovered from gas users via their gas bills over a period we assume is more closely aligned to the life of the BioSNG project; and
- Options B3, C1 and D1 score the best of the options because they spread the costs uniformly over the life of the BioSNG project (which we assume is likely to more closely align with the pattern of production of BioSNG by the project over its life).

[76] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/263937/Final_Document_-_Investing_in_renewable_technologies_-_CfD_contract_terms_and_strike_prices_UPDATED_6_DEC.pdf, p9.
[77] This assumes that BioSNG plants would be subject to the same approach to depreciation as other investments made by GDNs. However, as noted in Section 3.5.3, provision could be made for a bespoke depreciation period for BioSNG plants within the RIIO framework.

Table 8: Evaluation of options for stimulating investment in BioSNG – fairness

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Fairness										

Simplicity

All else equal, investors in BioSNG are likely to prefer a support mechanism which is simple to understand and operate. Therefore, options may be preferable if they are simpler than others. This would also be in line with Helm's Cost of Energy Review[78] for the government, one of the key findings of which was that complexity adds costs, and that government should simplify interventions where possible.

Out of the options presented, those that are the most straightforward, from the perspective of a BioSNG investor and developer, are the government support options (Options A1 and A2), and the higher gate fees to be paid by Local Authorities sending their residual household waste to be used as fuel to produce BioSNG (Option B4).

The other 'top-up' payment options (Options B1-B3) may be more complicated judging by counterpart mechanisms applied in other sectors, e.g., renewable electricity. Mitigating some of this potential complexity, it is envisaged that these options will be similar to previous and existing support mechanisms for low carbon electricity generation and therefore developers and investors will have some understanding of how they operate.

The options which are more interventionist, i.e., the guaranteed offtake arrangements (Option C1), and the regulated business models (Options D1-D3), are likely to be among the most complex options. This will stem from the process to set the offtake arrangements, and the regulated revenue streams. The fixed long-term cap and floor regulated revenue stream (Option D2) and the long-term regulated revenue stream, subject to periodic reset (Option D3) will also require monitoring by the regulator throughout the lifetime of the support mechanism. However, some of these complexities would be mitigated by the existence of similar regimes already, e.g., Option D3 would benefit from the fact it would be a simple extension of the existing gas distribution network regulatory regime to BioSNG.

[78] Helm (2017), Cost of Energy Review
https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/654902/Cost_of_Energy_Review.pdf

Table 9: Evaluation of options for stimulating investment in BioSNG – simplicity

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Simplicity										

Rate of return

On the face of it, the lower the cost of capital required for investing in BioSNG, the better. However, this over-simplifies the situation: allocating as much risk as possible to other stakeholders would enable investors in BioSNG to accept a lower rate of return, but allocating risks to the parties best placed to bear them is likely to lead to the best overall value for money as it incentivises investors to manage those risks and reduces the implications of stakeholders bearing risks they are not well placed to do so.

However, for the purposes of narrowly evaluating the options against the 'rate of return' criteria, a lower cost of capital is assumed to be better for stakeholders, with the trade-offs (e.g., via risk allocation) addressed through other evaluation criteria. Accordingly, options which require investors to bear more of the risks associated with the projects will need a higher rate of return in order to make the projects commercially viable, i.e., to compensate for those additional risks. The options which transfer the most risk to bill payers and/or taxpayers (such as the guaranteed offtake arrangements (Option C1) and the regulated business models (Options D1-D3)) would have the lowest costs of capital.

Table 10: Evaluation of options for stimulating investment in BioSNG – rate of return

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Rate of return[79]										

Revenue stability and predictability

Revenue stability and predictability are important to investors, particularly debt investors. Generally speaking, the more stable and predictable revenues are, the more stable and predictable returns to investors will be (though in some circumstances it would be more desirable to have a stream of revenues that automatically adjust to changes in costs). This is also likely to be the case for BioSNG investments, albeit there is – as discussed elsewhere – some uncertainty around the costs of BioSNG production over the lifetime of a project.

[79] For this evaluation criterion: a higher rate of return is considered a "weak contribution" and a lower rate of return a "strong contribution".

Assuming that revenue stability and predictability is a desirable feature of a support mechanism, those mechanisms which expose BioSNG investors to higher levels of price and volume risks will be less desirable, and those mechanisms which provide a more certain stream of revenues (de-linked from actual production and market prices) will be preferable. In this regard, the government support options (Options A1 and A2), and some of the top-up payment options (Options B1 and B4) provide less stable and predictable revenue streams than the top-up payment linked to the market price (Option B2) or to capacity (Option B3), the guaranteed offtake arrangements (Option C1) and the regulated business models (Options D1-D3).

The top-up payment options (Options B1, B2, B3 and B4) still expose investors to the operational risk of the plant, i.e., revenues are still dependent on the plant producing BioSNG (or at least being available to do so), while Option D2 would leave investors exposed to some merchant risk between the cap and floor revenue levels. Option D3 would expose investors to regulatory reset risk, i.e., since Ofgem re-determines revenues periodically under this model, there is some uncertainty about future revenues. This additional regulatory risk would have to be weighed against the greater flexibility it provides, e.g., ability to respond to unexpected changes in costs, which is discussed below.

Noting the above, the guaranteed offtake arrangement (Option C1) and the fixed long-term regulated revenue stream (Option D1) are the two options that seem likely to provide the most stable and predictable revenue streams for BioSNG investors.

Table 11: Evaluation of options for stimulating investment in BioSNG – revenue stability and predictability

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Revenue stability and predictability	○	○	◐	◐	◔	◐	●	●	◐	◔

Protection against asset stranding

Investors in technology may be concerned about rapid technological advancements making their investment uncompetitive and consequently unable to generate revenues. Protection against asset stranding may therefore be important to investors in commercial scale BioSNG, where both of these risks are present.

The different options for supporting BioSNG provide different degrees of protection against asset stranding. The options which leave investors exposed to price and revenue risks will also leave investors exposed to asset stranding risks. In this regard, the government support options (Options A1 and A2) provide little protection once the project is operational, but reduce the amount of capital at risk of asset stranding (either by reducing the amount of risk private investors contribute or by underwriting debt investors). Some of the 'top-up' payment options (Option B1, B2 and B4) are also highly exposed to volume risks as no revenue is earned or support received unless BioSNG is produced (or fuel is taken for the production of BioSNG), and provide the weakest protections. The fixed top-up for low carbon gas producing capacity (Option B3) provides additional protection because they reduce the price and volume risks, but investors continue to be exposed to the risk that the technology does not work: if the plant is not available to produce gas, they would not receive any revenue from the gas market and be penalised in accordance with the capacity market rules.

In contrast, the guaranteed offtake arrangement (Option C1) and regulated business models (Options D1-D3) provide the strongest protection against asset stranding, though these options are exposed to political and regulatory risk (linked to the possibility that the terms of government or regulatory support might be varied after the investment in BioSNG has been made). Options C1, D1 and D3 provide a guaranteed revenue stream regardless of whether the technology works, subject to any particular availability or performance targets that are embedded into those arrangements, e.g., Ofgem could set some kind of availability target as an output under the RIIO framework applied to GDNs. The cap and floor regime (Option D2) provides, via the floor revenues that ensure a minimum level of revenue for the BioSNG investor, strong protection against asset stranding, though it is not as strong as the protections under Options C1, D1 and D3.

Table 12: Evaluation of options for stimulating investment in BioSNG – protection against asset stranding

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Protection against asset stranding	◔	◑	○	○	◑	○	●	●	◔	●

Protection against unexpected costs

Investors in technology may be concerned about unexpected costs arising (e.g., to repair faults) in technology that has been proven at commercial scale, but is not yet mature, or that the technology costs do not reduce over time at the rate assumed by policy makers (and embedded in the level of support provided in future). Accordingly, the ability of the options to support BioSNG to adapt to changes in costs will be important to stimulating investment in BioSNG.

In this regard, options that leave investors exposed to more commercial risks are likely to be less accommodative of cost increases. If an investor in BioSNG is reliant on revenues from the gas market or gate fees that are effectively determined by the market (i.e., it is a price taker) then it will not be able to negotiate a higher revenue stream to accommodate any unexpected increase in costs. The government support options (Options A1 and A2) might therefore provide little protection against unplanned cost increases, unless BioSNG plants would have a degree of market power, i.e., an ability to influence the price at which they sell the gas they produce or the gate fees they receive for disposal of residual household waste.

Options for supporting BioSNG which provide a fixed price or fixed level of support over time would also be relatively inflexible to changes in costs. Policy-makers could potentially step in to revise the level of support (e.g., via a top up payment) or contracts could potentially be re-negotiated with local authorities to try and increase gate fees, but generally speaking the returns to investors in BioSNG would be directly impacted by any increase in costs if their revenues are fixed. Unless there are provisions to re-open the level of support provided in the event of a significant change in costs (perhaps similar to a force majeure or income adjusting event clause), the 'top-up' payment options (Options B1-B4) therefore provide only limited protection against unexpected costs. Given that the intention of the guaranteed offtake arrangements (Option C1) would seem to be to provide potential BioSNG investors with a strong incentive to invest in projects, we assume that these contractual arrangements may also include some mechanism whereby the level of support could be adjusted if there was a significant change in costs. Option C1 might therefore provide a stronger form of protection against unexpected costs than Options B1-B4.

The fully regulated revenue stream with periodic price control reviews (Option D3) provides the strongest protection against unexpected costs, partly because the regulator can adjust revenues more easily if costs increase, but also because there are mechanisms inherent in the regulatory framework that share a portion of cost overruns (and efficiency gains) with customers. The other regulated business model options (Options D2 and D3) provide a degree of protection against unplanned costs because there are provisions in the licenses for these regulated models (i.e., for OFTOs and for electricity interconnectors) which enable the revenue streams to be adjusted in the event of a material change in costs, but these are a weaker form of protection than those under a fully regulated option (Option D3).

Table 13: Evaluation of options for stimulating investment in BioSNG – protection against unexpected costs

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Protection against unexpected costs	○	○	○	○	○	○	◐	◐	◐	◔

Ease and pace of implementation

Given the challenges around decarbonisation of heat and transport, the potential role that BioSNG could potentially play in future and the state of development of BioSNG technology, there may be advantages to being able to introduce a support mechanism for BioSNG sooner rather than later. Accordingly, the speed and ease with which a mechanism could be implemented is important. However, implementing some of these options may be quicker and easier than others. For example:

- Some may require primary legislation to implement, while others might only require changes to regulations or expansions of existing schemes. For example, if BioSNG does not already qualify for support under the government guarantee (Option A1) and government grant (Option A2) schemes, it may be relatively straight forward to make this change.

- Some options may require more detailed consideration before they could be implemented. Extending existing schemes (Options A1 and A2) or adapting the RIIO price controls to apply to BioSNG investments (Option D3) may be relatively easy to do, while there would be lessons that could be readily learnt from other sectors when applying mechanisms that had been tried elsewhere (such as Options B1, B2, B3, C1, D1 and D2), though calibration of these mechanisms to apply to BioSNG would need to be carefully considered to ensure the best value for money for consumers and taxpayers (not least to take into account the revenues which BioSNG plants may be able to earn from gate fees – an additional source of revenue which has not typically been available when these kinds of schemes have been applied in other sectors). Option B4, as a bespoke mechanism developed specifically for BioSNG and with implications for local authorities and the waste sector in general, may require more extensive consideration before it could be applied.

- If it is assumed that it would be politically easier to recover the costs of supporting BioSNG through the bills paid by gas consumers, then options that do not recover the costs of supporting BioSNG from taxpayers may be preferred by government.

It might also be assumed that government would be more likely to support options that are similar to those it promoted in the past, e.g., the variable top-up payment option (B2) and

fixed top up payments for capacity (B3) are similar to the CfD and capacity market arrangements, respectively, which the government previously considered to be part of its preferred approaches to supporting renewable electricity.[80]

Further legal advice on these issues should be obtained and considered, but on the face of it the government support options (Options A1 and A2), and the long-term regulated revenue stream, subject to periodic reset (Option D3) appear the easiest and quickest to implement of the options considered in this report.

Table 14: Evaluation of options for stimulating investment in BioSNG – ease and pace of implementation

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Ease of implementation										

Encourage innovation

Driving the cost of BioSNG technology down over time will be critical to securing the best value for money for taxpayers and gas consumers. Accordingly, mechanisms for supporting BioSNG which place strong incentives on investors and the supply chain to find ways of reducing technology costs – and enabling the support mechanism to be reduced or removed – will be preferable. At the same time, however, mechanisms need to bring forward investments in BioSNG from which lessons can be learned – if no investment is stimulated then there won't be any lessons and technology costs will not be reduced over time. These objectives need to be carefully balanced. Here the ability of the mechanisms to spur innovation and cost reductions is considered.

Those options which leave investors exposed to more commercial risks (the government support options (Options A1 and A2), and the top-up payments (Options B1-B4) are likely to be the ones which spur the most innovation and reduction in costs over time, assuming that these mechanisms could bring forward investment in BioSNG from which lessons could be learned. Because these options would involve a higher degree of competition, rather than co-operation, between project developers, there is also a risk that these options would not lead to lessons being shared as widely as possible as quickly as possible, inhibiting the ability of the supply chain and the wider UK economy to benefit from the early commercial scale BioSNG projects.

On the other hand, options which do not expose investors to many commercial risks, such as some of the regulated business models (Options D1 and D3) or the guaranteed offtake arrangements (Option C1), might provide weaker incentives to reduce costs over time. This may be problematic in the longer term, but if these mechanisms could be accompanied by arrangements that would ensure lessons from the early commercial scale BioSNG projects were shared widely with other interested parties, some longer term benefits might be secured through these options. One way that these options could be implemented to ensure the beneficiaries of government support share their learnings with other potential project developers is via schemes similar to Ofgem's existing Network Innovation Competition and Network Innovation Allowance available to GDNs.

[80] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/42636/1041-electricity-market-reform-condoc.pdf, p5.

The fixed long-term cap and floor regulated revenue stream (Options D2) provides a degree of support to BioSNG somewhere between the lighter touch support mechanisms (Options A1-A2, and Options B1-4) and the fully regulated mechanisms (Options D1 and D3) or guaranteed offtake (Option C1) would share some of the advantages and disadvantages of both of these approaches. This option would provide more impetus to drive down costs than the other fully regulated options, but not as strong an impetus as the lighter touch support mechanisms. Similarly, this option may be more likely to stimulate investment in BioSNG than the lighter touch options, but would be less likely to stimulate investment – and the accompanying learnings – than the fully regulated options. The potential benefits for these options would need to be weighted carefully against the risks that these arrangements might not be sufficient to bring forward significant investment in commercial scale BioSNG technology that would enable lessons to be learned, and costs to be driven down, in the first place.

Table 15: Evaluation of options for stimulating investment in BioSNG – encourage innovation

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Innovation	●	●	◔	◔	◔	◔	◔	◔	◑	◔

Support to the supply chain and industrial strategy

The discussion above has largely focused on the direct benefits that a support mechanism could provide to BioSNG investors. There may, however, be spill over benefits (or externalities) to the BioSNG supply chain and to the wider UK economy as well.

These spill over benefits are likely to be largest for the UK economy where the mechanism supporting BioSNG is most effective, i.e., brings forward the largest amount of investment in BioSNG in the shortest space of time and if the investors are UK owned and operated. In that regard, those options which provide the strongest support to investors (the guaranteed offtake arrangements (Option C1) and some of the regulated business models (Options D1 and D3)), by transferring the most risk to other stakeholders, are likely to be the options which provide the strongest support to the development of a BioSNG supply chain capable of supporting both a UK industry and exports to the rest of the world.[81] Government debt guarantees and grants (Options A1 and A2) might also be capable of providing rapid support to the BioSNG industry, provided the amount of support offered is strong enough to catalyse investments, i.e., the residual risks which investors would be exposed to under these options would not deter them from bringing forward BioSNG investments.

Accordingly, these options (particularly Options C1, D1 and D3) might be those which are best placed to generate wider supply chain benefits and to help stimulate a BioSNG industry in the UK which could be exported to the world. The extent to which these mechanisms would be successful in supporting the supply chain and an export industry would depend on the way in which they were applied, e.g., the number of BioSNG projects approved by Ofgem, and the way in which the lessons from those projects were socialised with others (who might play a leading role in developing an export industry if GDNs did not want, or were not permitted to, play such a role) under Option D3.

[81] Any potential State Aid issues are outside the scope of this report.

Table 16: Evaluation of options for stimulating investment in BioSNG – supply chain and industrial strategy

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Supply chain & industrial strategy										

Summary

Table 17 below summarises the assessment above to provide a basis for broad comparison.

Table 17: Evaluation of options for stimulating investment in BioSNG

	Option A1: government guarantee of project debt	Option A2: government grants	Option B1: fixed premium to the market price of gas	Option B2: Variable top up payment linked to the market price of gas	Option B3: fixed top up payments for low carbon gas production capacity	Option B4: Higher gate fees for acceptance of waste from local authorities	Option C1 guaranteed offtake arrangements	Option D1: fixed long-term regulated revenue stream	Option D2: fixed long-term cap and floor regulated revenue stream	Option D3: long-term regulated revenue stream, subject to periodic reset
Customers and taxpayers										
Value for money (long-term)	◔	◔	◑	◕	◕	◑	◑	◑	◕	◑
Fairness	◔	◔	◕	◕	●	◑	●	●	◕	◑
BioSNG investors and developers										
Simplicity	●	●	◑	◑	◑	◕	◑	◑	◑	◕
Rate of return[82]	◔	◔	◑	◑	◕	◑	◕	◕	◑	◕
Revenue stability and predictability	○	○	◑	◑	◕	◑	●	●	◑	◕
Protection against asset stranding	◔	◑	○	○	◑	○	●	●	◕	●
Protection against unexpected costs	○	○	○	○	○	○	◑	◑	◑	◕
Government and regulators										
Ease of implementation	◕	◕	◑	◑	◑	◑	◑	◑	◑	◕
Innovation	●	●	◕	◕	◕	◕	◔	◔	◑	◔
Supply chain & industrial strategy	◔	◔	◑	◑	◑	◑	●	●	◑	●

Key:

○ No contribution ◔ Limited contribution ◑ Moderate contribution ◕ Significant contribution ● Strong contribution

[82] For this evaluation criterion: a higher rate of return is considered a “weak contribution” and a lower rate of return a “strong contribution”.

4.2 Options for supporting investment in BioSNG which stakeholders should consider further

As discussed above, there are advantages and disadvantages to each of the options. However, the options which provide the least risk protections (the government support options (Options A1 and A2) may provide too little support to BioSNG because private investors would still be exposed to material commercial risks around revenues and costs unless a significant portion of the project's capital would be contributed or underwritten by government. Government may be unlikely to contribute such a large amount of funding to BioSNG projects noting that recent support programmes have aimed to leverage the majority of funding from the private sector on the back of targeted financial contributions from government. For example, the government's Heat Network Investment Programme (HNIP) consultation indicated that it hoped to draw in an additional £2bn of capital investment on the back of £320mn funding from government (meaning government funding would amount to around 14% of total capital required).[83]

Of the remaining options for supporting BioSNG, there are trade-offs between protecting investors against risks in the short term and ensuring that market forces are harnessed to drive BioSNG costs down over time. Or, put another way, there are trade-offs between the contributions that bill payers and taxpayers make, and the risks allocated to them in the short-term and the benefits which they would hope to reap in the longer term. Securing the best value for money overall will require carefully allocating risks to the parties best placed to bear them, so as to protect investors against those risks which fundamentally undermine the case for investment in BioSNG, but at the same time expose them to an amount of risk which they can bear and which incentivises the investors to drive innovations and costs savings over time, as well as maximising revenues from the gas market and gate fees. For example:

- The options which provide the most protection to investors (the guaranteed offtake arrangements (Option C1) and some of the regulated business models (Options D1 and D3) are more likely to stimulate investment in BioSNG and have the lowest cost of capital, but come at the cost of losing some benefits from competition (in some cases), maximisation of revenues from gate fees and any efficiencies and innovation which exposure to market forces might create; and

- The options which provide some commercial protection, but still leave some exposure to market forces (some of the top-up payment options (Options B1, B3, and B4), and the fixed long-term cap and floor regulated revenue stream (Option D2) would be more likely to drive innovation and efficiencies over time, possibly making it more likely to enable withdrawal of support for BioSNG faster (as the technology may mature more quickly) than in Options C1, D1 and D3, but come at the cost of a higher cost of capital.

Government is likely to want to be able to gradually withdraw support over time as BioSNG technology matures (and becomes more cost competitive with other technologies), so is likely to want to expose BioSNG projects to some market forces in order to stimulate innovation and cost reductions. Options C1 and D1 might therefore be less likely to be acceptable to government because it may not deliver long term value for money for taxpayers and gas bill payers.

Government and Ofgem have typically favoured competitive bidding for support packages or regulated revenue streams in recent years (such as through the CfDs or the Capacity Market auction or for Offshore Transmission Owner (OFTO) or Competitively Appointed Transmission Owner (CATO) projects), rather than expanding the remit of regulated monopoly gas and electricity networks. Ofgem has also recently been resistant to electricity networks investing in battery storage projects.[84] There may, therefore, be some reservations about Option D3.

[83] See https://www.gov.uk/government/uploads/system/uploads/attachment_data/file/560597/HNIP_consultation_response-Final.pdf, pp5-6.
[84] See https://www.ofgem.gov.uk/publications-and-updates/enabling-competitive-deployment-storage-flexible-energy-system-changes-electricity-distribution-licence

Recent government support schemes for renewable electricity have favoured the use of a Contract-for-Difference (CfD) whereby prices per unit of generation are 'topped up' (or reduced) to the wholesale power price, rather than applying a fixed additional payment (like the Renewables Obligation (RO) which was the predecessor to the CfD).[85] Option B1 might therefore be less attractive than Option B2.

However, because options which continue to expose BioSNG to market forces are a weaker form of support for BioSNG than making it a fully regulated activity, the risks that these options would not stimulate investment in BioSNG – at least in the short term – are higher. The higher likelihood of stimulating investment in BioSNG provided by a fully regulated revenue stream would need to be weighed against any lower long-term value for money that such an approach might provide (noting that the fully regulated nature of the activity may mean it is less likely to stimulate innovation and cost reductions over time than support which continues to expose BioSNG to market forces).

Noting all of the above, in our view, a number of options are worthy of further consideration by policy makers and other stakeholders seeking to stimulate investment in BioSNG:

- The variable top-up linked to the market price (Option B2), the fixed top-up for low carbon gas producing capacity (Option B3), and the fixed long-term cap and floor regulatory revenue stream (Option D2), which provide some protection against extreme market risks, but which still expose investors to market forces, may provide an appropriate medium-term balance of risk between stakeholders that are capable of delivering the best balance of short term value for money and long-term innovation and efficiency. These options also potentially enable a degree of competition between investors seeking financial support, helping to achieve value for money for stakeholders; and

- Option D3 may enable BioSNG investments to come forward faster than any of the other options, as GDNs appear willing to invest in this technology (noting the number of GDNs currently participating in trials and pilots of BioSNG or other green gases) and there appear to be relatively few barriers to implementation. GDNs could be allowed to propose these investments as part of RIIO-GD2 business plans, or even over the remaining years of RIIO-GD1, for Ofgem to review and evaluate through the price control process. To maximize the benefits of supporting BioSNG in this way, Ofgem and other stakeholders should ensure that the benefits of the lessons learned from those early investments are made available to other potential developers.

If Options B2, B3 and/or D2 ultimately proved to be the most appropriate way(s) to stimulate BioSNG, support via Option D3 could be withdrawn, but the options are not mutually exclusive and there may be benefits to supporting BioSNG through multiple channels. All of these options should be considered further by government, Ofgem and the wider industry if a strategy is developed to support investment in BioSNG.

[85] We note that the National Audit Office recently suggested that the Hinkley Point C nuclear project could potentially have been delivered at a lower cost if alternative arrangements for financing this project had been considered: see https://www.nao.org.uk/wp-content/uploads/2017/06/Hinkley-Point-C.pdf. However, we consider that this recommendation was specific to that particular project rather than a general suggestion that the use of CfDs should be reduced and/or that government should generally contribute a greater share of capital to projects.

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