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David Curran
Clean Electricity Directorate, BEIS
1 Victoria St, London, SW1H 0ET

Dear David,

The ETI and ESC welcome the opportunity to respond to your consultation on proposed amendments to the Contracts for Difference (CfD) scheme.

The ETI and ESC support the proposal to update the definition of gasification to encourage deployment of more innovative designs. Key to this is incentivising gasification systems which use clean syngas to deliver higher end-to-end efficiencies and which could be used to produce other energy vectors, such as heat, biomethane and fuels. It is this flexibility which makes gasification an important, scenario resilient technology in the ETI and ESC's modelling of low-carbon energy system transitions.

However, we do not believe that the proposed approaches, as presented, will have the desired effect and will create unexpected and undesirable side effects. Only a criterion that requires a clean syngas to be produced at a point before use in generation will incentivise the innovations required to deliver significant future benefits. Hence, of the three criteria presented, we feel that the proposed Option B for Criterion 3 (specifying the end use of the syngas) is the easiest way to encourage syngas cleaning as this will be a requirement of the end conversion process. An alternative approach may be to specify a clean syngas quality on a sample taken just upstream of the point of final combustion based on the de minimis needs of those end uses (e.g. particulate matter loading maximum, sulfur maximum).

The greenhouse gas criteria under the CfD should encourage the use of feedstocks which deliver the greatest overall carbon reductions. However, as acknowledged in the consultation document, the greenhouse gas criteria calculation does not include carbon stock change or displacement effects. BEIS should reconsider the extent to which the limit is reduced, if presented with evidence demonstrating that feedstocks which could deliver a carbon saving when carbon stock change and displacement effects are taken into account, would be excluded by the lower threshold.

The ETI and ESC's joint response to the consultation is set out in Annex 1. We would be happy to discuss our response in person, or provide additional information in support of it.

Yours faithfully,

Geraint Evans, Programme Manager – Bioenergy and CCS, ETI
Hannah Evans, Practice Manager – Bioenergy, ESC

Annex 1: Responses to Consultation Questions

Wind on remote islands

Q.1 – Q.3: No response

Mitigating load factor risk

Q.4 – Q.7: No response

Advanced Conversion Technologies

Q.8 The government welcomes views on the proposed efficiency criterion, the proposed means of measuring it, whether there are other ways of measuring conversion efficiency that could be more effective, and whether it could be circumvented. Government also welcomes views and evidence on whether setting the conversion efficiency threshold at 60% is appropriate, or whether a different figure should be used.

The government states that the purpose of introducing an efficiency criterion for syngas production is to direct support to more efficient, innovative forms of ACT. However, measuring the efficiency around the gasifier (from feedstock to syngas production) does not guarantee that the end-to-end efficiency (feedstock to energy vector) will be high, nor that the technology will be more novel.

<u>It is important to differentiate between different gasification processes and their subsequent application</u>

The benefits of gasification, as a technology capable of producing heat, power, liquid and gaseous fuels, can only be realised if the raw syngas produced is cleaned up.

Gasification is a partial combustion process – some of the energy in the original fuel is not released and appears as a higher carbon content in the ash (compared to a well-run and efficient combustion process). To recover this loss (compared to a well-run and efficient combustion process) and more, the syngas must be used in a higher efficiency generating cycle. This is only possible with clean syngas.

Raw syngas comes out of the gasifier containing a variety of undesirable components including tars (which have high calorific value but are sticky and cause fouling downstream), particulates and chemical components which cause erosion and corrosion (e.g. silicas and alkali metal salts).

The degree to which syngas is cleaned depends upon the end use it is to be put to.

- If used raw and hot, then the syngas can only be used in a boiler – this is often called close coupled combustion/gasification. However, the undesirable components mean that the boiler needs to be derated (run at lower temperatures and pressures). Hence, the loss in efficiency as a result of the partial combustion process (i.e. gasification) is not regained. These systems have a lower efficiency than a well-run combustion process
- If used hot and cleaned but with the tars still present (in vapour form), the syngas can still only be used in a boiler. However, the boiler can be run much more efficiently as higher steam temperatures and pressures can be used without risk of excessive

corrosion and erosion rates. This is an efficient use of syngas, but the technology can only be used to produce heat and power.

- If the syngas is cooled, cleaned and has the tars removed, then the syngas can be used in an engine or a gas turbine – these can be more efficient routes to power than either of the two options above. The cleaned syngas could also be used in a chemical synthesis process, for example to make bioSNG or hydrogen or aviation fuel. In summary, gasification's full flexibility and resilience to future energy scenarios is only realised when the syngas is fully cleaned (tars removed and undesirable components removed to parts per million (ppm) or even parts per billion (ppb) levels in the case of, for example, sulfur).

In ETI's Insights paper, "Targeting new and cleaner uses for wastes and biomass using gasification,"[1] we refer to these three types as Type 1, 2 and 3.

<u>The current proposal to set an efficiency measured around the gasifier only is unlikely to differentiate between the types of gasifier BEIS wishes to encourage (Type 3) and those that are too closely related to combustion (Type 1).</u>

If an efficiency criterion is important to BEIS, then it should cover the whole site and great care must be taken to ensure consistent system boundaries. Setting consistent system boundaries, whether around part of the gasification system (e.g. from feedstock hopper to raw syngas) or around the whole gasification system (e.g. from feedstock hopper to net power produced), will be challenging to define and implement. It is difficult, if not impossible, to define consistent system boundaries to enable rigorous comparison between different gasifier types.

The ETI and ESC have identified the following risks associated with this first (efficiency) proposal:

1. If cold, clean syngas efficiency for use in a Type 3 system is compared against hot, raw syngas efficiency for use in a Type 1 system, the types of gasification system the government wishes to encourage (Type 3) will appear to have a lower efficiency using the proposed efficiency metric. This is because the removal of tars to prevent downstream fouling, reduces the overall calorific value (CV) of the syngas.

2. If the proposed efficiency metric measures efficiency up to the point of producing raw syngas (pre-clean up), there will be little difference in efficiency between Type 1, 2 and 3 gasification systems. The gasification reactors are often very similar across all three types.

3. Smaller plants are likely to have lower efficiencies on a unit basis than larger plants (increased heat losses are one key reason). However, smaller plants can have benefits over larger plants, including reduced waste miles and greater opportunity to operate

[1] ETI (2017). Targeting new and cleaner uses for wastes and biomass using gasification [online]. Available at: http://www.eti.co.uk/insights/targeting-new-and-cleaner-uses-for-wastes-and-biomass-using-gasification

as a CHP plant, as they are small enough to be situated within industrial parks. These benefits should be taken into account.

4. It is unclear why 60% has been chosen.

On a related note, the ETI/ESC feel that the current methodology for defining "ROC-able" power from gasification plants drives inefficiencies. This methodology allows energy recovered from an engine exhaust and cooling system to be used, for example in an Organic Rankine Cycle process, to generate additional and "ROC-able" power. However, by only focussing on part of the gasification plant system, this methodology effectively prevents plant owners from integrating heat flows from across the whole site. As a result of this failure to consider the plant as a whole system, the ETI have calculated that this results in an overall plant efficiency loss of around 1 percentage point.

In conclusion, measuring just the efficiency around the gasifier does not define a "good" process as the whole system efficiency might be poor even though energy recovery across the gasifier is apparently high.

The ETI and ESC recommend that any efficiency measure considers the whole site, from feedstock to energy vector, accounting properly and consistently for parasitic loads (e.g. accounting for the difference between electricity imported from the national grid and use of a plant's self-generated electricity).

Q.9 The government welcomes views on the additional measure for plants with mixed feedstocks, including whether C12:C14 testing is an appropriate and reliable way to establish the biogenic fraction of the syngas or synliquid for plants using waste, and on whether there are better approaches establish the biogenic fraction of the syngas to a reasonable level of accuracy.

The ETI/ESC agree that there is a risk that biogenic and fossil components may react differently in gasification. This risk though may be different for different types of gasification, in particular between allothermal (gasification by pyrolysis reactions only) and autothermal gasifiers.

In autothermal gasification, secondary and tertiary reactions within the gasifier may result in a more equal conversion of fossil and biogenic carbon to syngas (gas/solid phase reactions). In allothermal gasification, there may be a more unequal distribution if fossil material more easily converts to gas.

The ETI and ESC recommend that the government commissions research to test the extent to which biogenic and non-biogenic feedstock fractions are converted to syngas, and whether this differs across different types of gasification.

Q.10 The government welcomes views on whether there are sufficient incentives on the efficient generation of electricity for ACT for an efficiency threshold not to be required at this stage of the production process

At present, there is no efficiency target for ACTs and unfortunately, current incentives allow low efficiency systems (close coupled technologies) to qualify as ACTs. As these systems use the syngas they generate in its raw, uncleaned state, there is no ability to use the syngas in a high efficiency generating cycle downstream (such as a high pressure/high temperature boiler or an internal combustion engine).

As stated in the response to Question 8, the proposed efficiency measure (calculated as "energy in syngas divided by energy in feedstock") will, at best, not differentiate between systems with lower overall efficiency ("close coupled", referred to as Type 1 in the ETI's Insights paper[2]) and higher overall efficiency (using clean syngas in an engine or gas turbine (Type 3)). At worst, close coupled systems could appear to have a higher efficiency than more novel, efficient systems (Type 3) if the proposed efficiency measure uses the calorific value of the cleaned syngas (because it has a lower CV than raw syngas) .

The ETI and ESC recognise that the driver behind introducing an efficiency criterion is because, for energy from waste plants in particular, efficiency is not always rewarded by increased total revenues; increased power income may not balance the loss of gate fee income for waste fuelled plants and is likely to increase the capital cost of the plant. Higher efficiency is too costly to achieve with less innovative processes and innovation is required to deliver efficiency cost effectively. However, the risk with secondary targets is that gaming will enable them to be met with configurations of established technologies which have a lower system efficiency.

If an efficiency threshold is to be used, then whole plant efficiencies should be considered and system boundaries defined with care and in detail. A detailed study will need to be prepared by BEIS to achieve this as calculating comparable efficiencies between different plants of different types is extremely challenging. Furthermore, setting a single efficiency threshold will also be difficult as smaller plants with their higher parasitic loads per kWh could be penalised. A single efficiency threshold might drive developers to build larger plants and so disincentivise the development of innovative town scale projects with their ability to more easily deliver CHP.

As efficiency can be more easily compared between different time periods for one site, an alternative approach may be to require project developers to demonstrate the best efficiencies (range) possible from their plant and to provide evidence during operations that efficiencies have been maintained in the acceptable range.

[2] ETI (2017). Targeting new and cleaner uses for wastes and biomass using gasification [online]. Available at: http://www.eti.co.uk/insights/targeting-new-and-cleaner-uses-for-wastes-and-biomass-using-gasification

Q.11 The government welcomes views on the proposal to set a maximum level of incombustibles in syngas or synliquid

As set out in the response to Question 8, more efficient and flexible syngas applications require cleaner syngas. However, the specific composition requirements for syngas and synliquid will depend on the needs of the end application.

The proposal to define the quality of a syngas, by setting a limit on the level of incombustibles (listed as carbon dioxide, nitrogen and water in the consultation, but which also could include ash particles) is not suitable for gasification-to-power applications as it risks excluding some novel, efficient technologies, whilst opening the door to gaming from less efficient applications.

For example, a small scale gasifier, using a homogeneous feedstock and combusting the syngas (post-cleaning) in an engine, might consider using air-blown gasification (since using oxygen at this scale is classically thought of as too expensive). This type of technology is an efficient end-to-end process but would produce a syngas containing up to 50% nitrogen. UK companies offering this technology include Refgas and Abor Heat and Power (modules are 800 kWe max but could be multiplied up). Under the current proposal, this type of system would be excluded, despite being a more efficient system than close-coupled gasifiers.

An alternate method of gasification at these smaller scales is gasification by pyrolysis (allothermal gasification). Here, heat only is used to thermally decompose the wastes or biomass to yield a tarry gas which, when cleaned up, can be used in an engine, or if used raw, directly in a boiler. The gas will contain very little carbon dioxide and no nitrogen (as no air was used in the process). Char (sometimes referred to as biochar) is also sometimes produced as a product.

If a maximum level of incombustibles is set and this includes nitrogen, then air-blown gasification could be closed off as a technology in the UK and gasification by pyrolysis technology providers could be advantaged.

At larger scales, nominally about 10 MWe of electrical output, oxygen-blown systems become much more common. Inefficient, close-coupled gasifiers, are typically air blown, but could use oxygen enrichment to achieve an incombustibles "target". Project developers have previously considered using oxygen enriched air in these systems to ensure a high enough syngas CV when there was a 4 MJ/m^3 target.

Overall, defining syngas quality by its level of incombustibles is not an appropriate way to differentiate between more efficient and flexible gasification systems, and low efficiency systems. This is not least because the ability to use a syngas efficiently is more driven by its cleanliness and some of the most important elements to remove during syngas cleaning (when using the syngas in an engine or gas turbines) are combustible compounds such as tars.

The ETI and ESC would recommend basing any syngas quality criteria on the likely requirements for efficient end applications. The current proposal is based on limits for injection into the gas grid. This is irrelevant in the context of the Contracts for Difference scheme as the syngas will be produced and combusted on a single site.

Q.12 The government welcomes views on the proposed level of 20% and whether this a suitably ambitious but achievable threshold

As stated above, the ETI and ESC do not recommend introducing a limit on the level of incombustibles in syngas.

A downdraft air blown gasifier will produce a syngas containing around 40-50% nitrogen. If the nitrogen is classified as an incombustible and the maximum level is set at 20%, then this class of gasifier will be discouraged, even though it can produce a syngas suitable for some efficient end-use applications. This may have a damaging impact on smaller gasification developers in the UK such as Refgas and Abor Heat and Power and advantage others who's technologies use "gasification by pyrolysis".

Q.13 For processes that produce liquids or mixtures of liquids and gases, the government welcomes evidence on the proposed maximum allowable amount of non-combustible material in the liquid (such as water) and on whether it is worth testing liquids for non-combustible material.

No response

Q.14 The government welcomes information on the availability of laboratories that would be capable of carrying out these tests, and the likely cost of testing

No response

Q.15 The government welcomes views on Criterion 3, including on the relative merits of Option A, Option B and any other potential approaches, on the ease of implementing these measures, and the extent to which compliance could be circumvented.

Option A. Defining what "separate" means will be challenging. It may be open to gaming through "creative" plant design.

Option B. This option effectively defines the syngas "quality" since the options shown (engine, turbine, fuel cell) have specific and detailed requirements. E.g. ppm/ppb on tars. However, the ETI and ESC understand that there are risks in "choosing" end uses when the objective is to define gasification. The ETI and ESC anticipate that Option B would be relatively easy to implement but might need to include a mechanism to allow new technologies to be added to the listed following an appropriate review process.

Building on Option B, the ETI and ESC propose an alternative approach in which the syngas quality is specified on a sample taken just upstream of the point of final combustion based on the de minimis needs of those end uses (e.g. particulate matter loading maximum, sulfur maximum). To deliver this, BEIS should commission a study to:

1. Understand the syngas quality requirements for each of the target end uses.

2. Identify levels of common, identifiable and measurable components. e.g. sulfur, tars, particulates, alkali metals, and use this to define a cleaned syngas quality threshold.
3. A CV threshold would also need to be included to ensure that a clean gas containing chemical energy is produced (and not just a clean flue gas).

Q.16 The government welcomes views on the likely impact of this criterion on what types of project would be eligible to receive CfD support, and whether this change would encourage generators to carry out further clean-up or processing of the syngas

Option A would not encourage generators to clean up the syngas as it only asks them to have a separate unit for producing the syngas and a separate unit to burn it.

Considering this criterion alongside the efficiency and syngas quality criteria (as proposed), the combination is unlikely to encourage the deployment of efficient, novel technologies. The efficiency criterion as currently proposed would not encourage generators to carry out further clean-up or processing of the syngas as close coupled gasifiers could achieve a cold syngas efficiency of over 60%. A whole-site (feedstock to end vector) "whole system" efficiency threshold is needed to understand whether a gasification plant is efficient or not.

The proposed quality criteria could possibly be gamed by using oxygen-blown gasifiers in close-coupled applications. Additional criteria that requires syngas clean-up would be required to meet the government's objectives.

An alternative criterion might be to require some degree of syngas cooling between the two vessels. However, there is a high risk of gaming through the use of heat recuperation.

Option B would encourage generators to clean up the syngas as they would not be able to reliably fuel an engine, turbine or fuel cell with a raw syngas.

Q.17 The government welcomes information on any known close-coupled combustion ACTs that could be clearly differentiated from direct combustion technologies, and capable of delivering affordable and efficient low-carbon electricity.

It should be made clear that close coupled gasification technologies involve no syngas cleaning steps. The syngas produced is used hot and raw and the full benefits of using gasification (efficiency and flexibility to produce different end products) are not realised.

It is possible to clean the syngas hot with the aim of burning the hot cleaned up syngas in a boiler. The objective of cleaning the syngas hot is to permit higher steam temperatures and pressures and so yield higher efficiencies to power from the steam. Higher performance is made possible because the undesirable elements within the raw syngas which cause erosion and corrosion in the boiler are removed from the syngas before combustion. This type of system is described as Type 2 in the response to Question 8 and in the ETI's Insights Paper[3]. It might be (but should not be) confused as being a close coupled system.

A Type 2 system should be encouraged for use in district heating. Because of the lack of district heating in the UK, there has been little or no uptake in the UK. Type 2 systems are used more widely in the Nordic countries where Valmet is a well-known and respected technology provider. An example is the Lahti gasification plant[4].

Q.18 Views are welcomed on the relative merits of the three options for frequency of sampling, whether they provide a suitably robust measure at a reasonable cost, and whether there are any other means of sampling or demonstrating compliance that may be preferable. The government is also seeking views on the possibility of monitoring processes on a continuous basis (for example, whether this is already undertaken for quality assurance processes).

We recommend that if tars or particulates are to be measured, then iso-kinetic sampling should be used to ensure a representative sample.

Q. 19 Views are welcomed on the proposed penalties for non-compliance with these criteria

No response

Combined Heat and Power

Q.20 – Q.25: No response

[3] ETI (2017). Targeting new and cleaner uses for wastes and biomass using gasification [online]. Available at: http://www.eti.co.uk/insights/targeting-new-and-cleaner-uses-for-wastes-and-biomass-using-gasification

[4] https://www.lahtigasification.com/

Greenhouse gas criterion for solid and gaseous biomass

Q.26 The government welcomes views on all aspects of the proposed approach, including:

> *a) setting a new (and lower) criterion than the one used up to now*
>
> *b) using recent performance under the existing criteria as a basis for defining a new criterion*
>
> *c) defining a single criterion applying across five commissioning years*
>
> *d) setting a criterion that will remain constant for the duration of a 15 year CfD contract*
>
> *e) which of Option 1 and 2 appears most appropriate*
>
> *f) the proposal to not to change the emissions limit for single consignments*
>
> *g) scope for unintended consequences*

Bioenergy is a hugely valuable source of low carbon renewable energy because it can be stored and used flexibly to produce heat, power, liquid and gaseous fuels. When combined with carbon capture and storage (CCS), it has the potential to deliver negative emissions which the ETI anticipates are needed to deliver a cost-effective, low carbon energy system in 2050.

The ETI's internationally peer-reviewed Energy System Modelling Environment (ESME), a national energy system design and planning capability, suggests that bioenergy, in combination with CCS, could provide around 10% of projected UK energy demand (~140 TWh/yr) whilst delivering net negative emissions of approximately -40 Mt CO_2 per year in the 2050s. This is roughly equivalent to half the UK's emissions target in 2050 and reduces the need for other, more expensive, decarbonisation measures.

Using bioenergy in this way could reduce the cost of meeting the UK's 2050 greenhouse gas (GHG) emissions reduction target by more than 1% of gross domestic product (GDP). Even in the absence of CCS, bioenergy is still a cost-effective means of decarbonisation and should play an important role in meeting the UK's 2050 emissions target.

While ensuring that new bioenergy plants deliver significant GHG emissions savings is important, the ETI and ESC argue that to realise the greatest benefit from bioenergy, the UK needs a strategy for bioenergy deployment that focuses support on deploying technologies in locations which set the UK on a trajectory towards delivering Bioenergy with CCS (BECCS).

As set out in the ETI's Insight paper, *The evidence for deploying BECCS in the UK*[5], the UK is in a strong position to realise the benefits of CCS and BECCS, given its significant offshore storage capacity and experience from the Oil and Gas sector. The ETI's analysis suggests that the key to reducing the cost of CCS lies in now delivering a small number of large plants sequentially[6].

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[5] ETI (2016). The evidence for deploying BECCS in the UK [online]. Available at: http://www.eti.co.uk/insights/the-evidence-for-deploying-bioenergy-with-ccs-beccs-in-the-uk

[6] ETI (2017). An argument for CCS in the UK [online]. Available at: http://www.eti.co.uk/library/an-eti-perspective-an-argument-for-ccs-in-the-uk

The GHG criteria under the CfD should encourage the use of feedstocks which deliver the greatest overall carbon reductions. Lowering the emissions threshold should encourage reductions in those activities covered by the GHG criteria. However, as acknowledged in the consultation document, the GHG criteria calculation does not include carbon stock change or displacement effects. BEIS should reconsider the extent to which the limit is reduced, if presented with evidence demonstrating that feedstocks which could deliver a carbon saving when compared to likely alternative scenarios (counterfactuals) taking carbon stock change and displacement effects into account, would be excluded by the lower threshold.

Changes to improve the operation and clarity of the CfD

Q.27 – Q.31: No response

Q.32 The government welcomes views on the proposal to amend the definition of 'waste' in the Eligible Generator Regulations and the CfD Agreement to bring it into line with the new 'waste' definition in the Renewable Energy Directive. The new definition would apply for all purposes where the word 'waste' is used in the CfD scheme.

The ESC agrees with the proposal to tighten the definition of 'waste' to prevent deliberate contamination of non-waste feedstocks in order to avoid meeting sustainability criteria.

Where waste and non-waste materials are used in the same conversion process the sustainability of each material stream should be calculated separately.

Q.33: No response

Annex 2: About the ETI and ESC

Energy Technologies Institute (ETI): The ETI is a public-private partnership between global energy and engineering firms (BP, Caterpillar, EDF Energy, Rolls-Royce, and Shell) and the UK Government. Our mission is to accelerate the development, demonstration and eventual commercial deployment of a focused portfolio of energy technologies which will increase energy efficiency, reduce greenhouse gas emissions and help achieve energy and climate change goals.

We carry out three key activities:

- modelling and strategic analysis of the UK energy system to identify the key challenges and potential solutions to meeting the UK's 2020 and 2050 targets at the lowest cost to the UK
- investing in major engineering and technology demonstration projects to de-risk and build capability in both technology and supply-chain solutions for subsequent commercial investors
- enabling effective third party commercialisation of project outcomes.

The ETI developed an internationally peer-reviewed national energy system design tool (known as 'ESME' - Energy System Modelling Environment), to underpin our strategic techno-economic analysis of the UK energy system. ESME models choices across power, heat, transport and infrastructure sectors and is informed by evidence drawn from our private sector members, our technical projects and a range of expert advisers. As such it has enabled the ETI to deliver evidence-based insights on how to deliver affordable, secure and low carbon energy for Britain in the decades ahead, including identifying credible, lowest-cost pathways to secure low-carbon energy in future.

The ETI was established as a fixed-term partnership operation which will come to an end in December 2019. To continue the legacy beyond the ETI, in September 2017 the ETI's whole system analysis capability including its ESME modelling team was transferred to the ESC to ensure that it can continue to use its capability to support the transition of the UK energy system.

Energy Systems Catapult (ESC): The ESC supports innovators in unleashing opportunities from the transition to a clean, intelligent energy system.

Part of a network of world-leading centres set up by the government to transform the UK's capability for innovation in specific sectors and help drive future economic growth. By taking an independent, whole energy systems view, we work with stakeholders across the energy sector (consumers, industry, academia and government) to identify innovation priorities, gaps in the market and overcome barriers to accelerating the decarbonisation of the energy system at least cost. In doing so, we seek to open up routes to market for innovators, as well as supporting them to understand how their products, services and value propositions fit into the transforming energy system.

Written evidence submitted by Geraint Evans on behalf of the ETI and Hannah Evans on behalf of the ESC, February 2018.

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