Progressive Energy Response to the CCC Bioenergy call for Evidence February 2018

Background to Progressive Energy

Progressive Energy is an established independent UK clean energy company focusing on deployment of emergent technologies and associated project development and implementation. It has particular expertise with regard to advanced technologies such as gasification, as well as conventional biomass heat and power. It has pursued Carbon Capture and Storage since 1998 with an international reputation in the sector in particular associated with capture from industrial processes and activities relating to decarbonised hydrogen production. It also provides advisory services, in particular providing expert due diligence to a range of investors considering investments in new low carbon and renewable technologies. It undertakes advisory work for policymakers and is a founding member and on the industrial advisory board for the EPSRC Supergen Bioenergy Hub.

Since its inception in 1998, Progressive Energy has always been active in the sector of thermal conversion of solid feedstock to syngas and subsequent upgrading. In 2010 it undertook a feasibility study with CNG services for National Grid, Centrica and the North East Process Industry Cluster (NEPIC) into the production of Bio- Substitute Natural Gas (BioSNG) for heat and transport. BioSNG is biomethane produced by thermal means, as opposed to Anaerobic Digestion. This approach produces the same fungible natural gas fuel, but uses a wide range of feedstocks including residual mixed waste, enabling production of significantly greater quantities of gas in the UK.

Since 2012 it has worked in consortium with Cadent and Advanced Plasma Power to deliver initially a pilot plant funded through BESTF and OFGEM's Network Innovation Competition (NIC). The consortium is now delivering the world's first full-chain, waste-fuelled BioSNG full chain plant, taking residual waste input and producing contracted renewable gas output. This is funded by both Department for Transport (under the Advanced Biofuels Competition) and NIC. This facility will be operational in 2018 and produce 22 Giga-watthours of gas per annum. The facility will deliver gas both to a haulage company with an existing Compressed Natural Gas (CNG) fuelling station, to convert their HGV fleet to renewable gas, and to the local gas grid for heat consumers. Further information about these projects can be found at http://gogreengas.com/

In the following, we have responded to questions: 14, 15, 23, 24, 25, 26, 27 & 28.

14. What are the most credible and up-to-date estimates for the amount of bioenergy resource that could be produced from UK waste sources through to 2050? Where possible please state any assumptions relating the reduction, reuse and recycling of different future waste streams.

A range of assessments have been done since the CCC undertook its work in 2011. One of the most recent was undertaken by Cadent, which we project managed on their behalf, which can be found at https://cadentgas.com/About-us/The-future-role-of-gas/Renewable-gas-potential. This report carefully reviews assumptions, including waste assumptions as well as economic growth and population. We are also aware that BEIS has also done a similar assessment, and assume that the CCC also has access to this.

15. What factors (opportunities, constraints, assumptions) should the CCC reflect in its bioenergy resource scenarios through to 2050?

There are some key factors which the CCC should consider carefully:

- **Opportunity.** Biomass is nature's elegant biochemical and self-replicating means of fixing carbon dioxide and sunlight into a carbon and energy rich material. It offers two utility functions: (a) the opportunity to remove carbon from the atmosphere and store it by various means and (b) a vector for sunlight energy which avoids adding to the carbon content of the bio-sphere.
- **Optimisation in a constrained world.** We must view these functions strategically in light of key constraints: (a) biomass being a finite resource which needs stewarding (b) the need for and limited alternative opportunities for carbon removal from the biosphere and (c) the needs and limited opportunities for avoiding new carbon emissions to the biosphere from certain parts of our energy system.
- **Practical pathways.** We must also recognise that strategic goals are critical, but it is vital that practical pathways are found to meet those goals. Assuming a future step change from current modus operandi to a strategic nirvana state has two major flaws;
  - (a) bioenergy is a complex system from cultivation (and intermediary use as for waste) through supply chain to conversion to energy and carbon storage which also sits alongside agriculture, social systems etc. It is highly unlikely that a step change can be delivered through a system. Without practical progressive approaches, the strategic outcome is extremely unlikely.
  - (b) Carbon impacts are so pressing that incremental savings are required today, with a progression to deeper savings in the future. Discounted carbon flow analogy is helpful; means of achieving moderate savings today can be as valuable as deeper savings in the future, providing that the approaches today do not directly conflict with achieving required future outcomes.

  As is also well documented, it is critical that biomass usage is sustainable in its widest sense particularly in the through system carbon implications, but also the wider environmental and social factors.
- **Implications.** This view leads to a number of guiding principles for practical direction:
  - **Electricity.** Significant progress is being made, particular via wind and solar, in reducing the carbon intensity of this sector. The residual need is storage and flexible generation. Burning biomass to generate electricity only does so relatively inefficiently and is not an ideal solution to bridge this gap. Particularly since capture of CO_2 from dilute atmospheric flue gases (a) will inevitably reduce efficiency significantly and (b) will substantially hinder flexibility. Whilst this has historically been a helpful sector to establish sustainable supply chains, future developments should build on this supply chain and strategically direct bioenergy to sectors with more pressing demands:
  - **Heat.** UK heat supply is dominated by gas which well-matched to its housing stock with associated consumer and national infrastructure. There are myriad practical reasons why this will be a challenge to change this (consumer behaviour, slow change of housing stock, end user impactions for major changes to heating systems, magnitude of consumption, consumption patterns and delivery capability for switching to electricity etc). Therefore, whilst there is undoubtedly a role for electrification this may be practically limited. Direct combustion of biomass to heat may have some niche opportunities such as in some industry, but certainly in the domestic environment presents significant air quality risks. Conversion of bioenergy to alternative has a number of advantages: Today it can be used to provide a fungible alternative to gas today (AD and BioSNG) with conversion 2-3 times more efficient than conversion to electricity and this transition leads to rejection of approximately half of the carbon in process, so provide CO_2 capture at no additional energy/cost

penalty. In the future this could be taken to the limit of converting to hydrogen at higher efficiency of conversion and capture of all the carbon. It should be noted that such gas vectors with CCS can provide a better solution for flexible power generation compared with post combustion capture, so this can still feed back into the electricity sector if necessary.

- **Transport.** Good progress is being made towards electrification of passenger vehicles. This is expected to form a part of the transport solution, addressing both carbon and air quality issues. Solutions for LGV and particularly HGVs is more elusive, with payload and charging times being significant barriers. Biomethane offers a solution for today, again made even more valuable with sequestration of CO_2 from production. Hydrogen is a solution for the future. Liquid biofuels could also play a role in this sector. Arguably the higher carbon intensity of liquid fuels reduces the opportunity for CO_2 capture. This is more likely to be driven by the desire for aviation fuel, assuming that deep decarbonisation elsewhere does not allow this harder to reach sector to use some fossil resource.
- **Other.** Biomass provides a carbon-based material, either for direct use or potentially conversion to other materials via C1 chemistry. If use of biomass in this way (a) genuinely avoids carbon intensive alternatives which lead to fossil emissions and (b) genuinely stores carbon over a material timeframe, then clearly this is an important role. In evaluating this role it is important (a) just like any other vector to fully account for the sustainability of use and (b) recognise that in its raw form only a subset of biomass is suitable. Most biomass is *not* suitable in its raw form for construction; additionally production of construction biomass will itself lead to rejection of significant quantities of biomass which is also not suitable. The types of assessment of resource undertaken in the bioenergy review referred in Q14 rightly focuses on only the resources not suitable for this use.

- Biomass directed towards the energy sector should therefore be converted to heat or transport fuel vectors, initially still including biocarbon (whilst ideally sequestering the rejected carbon in conversion from solid biomass to inevitably less carbon intensive vectors) and ultimately transition to hydrogen with the biocarbon fully sequestered. This is a logical pathway, establishing wide elements of the supply chain incrementally, with no regrets progress today and deepest carbon benefits in the future.

23. Gasification has been identified as a potentially important technology for unlocking the full potential of bioenergy to support economy-wide decarbonisation.

Strategic background has been laid out in Q15.

a) What are the likely timescales for commercial deployment of gasification technologies?

Gasification has the potential to deliver substantial deployment during the 2020s making an important contribution to the UK's 4th and 5th carbon budgets as well as 2030 renewable aspirations

Gasification of coal has been established for over a century and used commercially to provide syngas for upgrading for chemicals processing and conversion to substitute gas. For example, the 3GWth Dakota synfuels facility in the US has operated for over 30 years taking low grade lignite, gasifying to a syngas which is methanated and upgraded for distribution using pipeline, with the arising CO_2 sequestered.

To apply the process to biomass and waste resources requires two primary differences (a) the scale of facilities is much smaller to match feedstock arisings, typically measurable in 5-100MWth and (b) such feedstocks cannot be gasified using conventional coal gasification systems. This requires therefore suitable gasification systems.

There are good examples internationally of BioSNG processes operating on biomass feedstocks, notably a pilot plant at Gussing, and a 20MWth facility in Gothenberg run by Gobigas. Both these facilities successfully convert wood residue pellets through gasification and methanation to a fungible biomethane; at Gobigas, the product is physically injected into the grid and distributed to users. Unfortunately, the cost of the feedstock and the current support structure means it is challenging economically to operate this plant, although companies participating in Gobigas, such as Valmet, are interested in further deployment in markets where BioSNG is commercially attractive.

Other international companies active in delivering BioSNG facilities include Dahlman who have been working closely with ECN in the Netherlands over many years and are developing a waste wood SNG facility.

In the UK, the Cadent, Advanced Plasma Power & Progressive Energy consortium a commercial demonstration plant under construction. In 2018, this facility will physically inject biomethane into the gas grid for distribution to customers, as well as directly delivering gas for transport applications (see http://gogreengas.com/). The consortium has a fully delivery strategy for deployment, including commercial plant design and associated procurement approach using major contractors capable of delivering plant and equipment under suitably guaranteed contractual arrangements. First large scale commercial projects will reach financial close in 2019.

In addition to integrated BioSNG facilities, there are also successful integrated, thermal biofuels facilities such as the Enerkem plant in Edmonton which is gasifying MSW into catalytic quality syngas and then catalytically converting it to biomethanol. Enerkem is currently focusing on alcohol production, but their process is readily adaptable for the production of biomethane.

b) What efficiencies and costs are likely to be achieved? What scope is there for improvement and/or cost reductions over time? Please differentiate between feedstocks where possible/necessary.

This is well documented in the BioSNG & biohydrogen reports http://gogreengas.com/downloads/.

Cold gas efficiencies in excess of 80-85% are typically achievable on an HHV basis from feedstock to product gas. From the work described above, where the product is taken to hydrogen HHV efficiencies 79% of from feedstock to product and for BioSNG around 64% on the same basis.

In general, the differences between waste and non-waste feedstocks are relatively marginal. If the syngas is to be used for catalytical upgrading, then even 'pure' biomass contains sufficient contaminant to poison catalysts, so both require extensive syngas processing. Arguably the higher ash content of a waste feedstock may lead to slightly higher thermal losses, but this is considered to be a second order effect.

c) What are the main barriers and uncertainties associated with the development, deployment and use of gasification technologies?

- Policy barriers: See response to Question 23 (e)
- Technology and commercial barriers: See response to Question 23 (d)

d) What risks are associated with gasification technologies and how can these be managed?

- **Technical risks:** Relate primarily to providing high quality syngas with low tar that can then be upgraded using conventional chemical processing. There should be targeted demonstration support to enable gasification systems which process tar effectively. Whilst the Swindon BioSNG project is a useful example, if the UK is to adopt this more widely, other projects are necessary to establish a wider technology base.
- **Resource risks:** Although there is currently under capacity in waste processing in the UK, with >3 million tonnes of RDF exported, this situation is reversing with construction of conventional EfW plant. This resource should be viewed strategically, and policy should be developed accordingly, with close co-operation between BEIS, DEFRA and DFT.
- **Commercial risks:** poorly defined incentive structures which have driven perverse behaviours. Support under the CfD should be removed, and support which drives gas towards heat and transport fuels developed.
    - Fundamentally, per unit incentives are well placed to drive deployment and drive down costs of relatively mature technologies. Targeted capital or favourable loan support is preferable to drive development of newer technologies, although it is recognised this may be more challenging to put in place.
    - For Heat a new support mechanism is required, given the imminent end of the RHI. Like for electricity there is an almost unlimited market for fungible gas; production of biomethane from gasification (as well as AD) should be supported, but focused on the needs of the individual technologies.
    - For Fuels, the Dev RTFC is promising, but it is reliant on there being a sufficient market for the fuel, which is a risk in the development stages. This requires end users to invest in gas trucks; at a minimum the duty differential needs to be retained, and arguably additional support (loans?) for operators to make the slightly higher initial vehicle investments.

e) What policies and incentives are required to facilitate commercial deployment?

The UK has had a chequered history with biomass and waste gasification. The preferential treatment provided by the Renewables Obligation was a seemingly good idea, to try and pull the technology through. However, over the last decade this has been completely confused policy-wise, leading to:

- Development of projects focused on 'chasing' the incentives, typically in the early stages by developers without the understanding and expertise in the technology.
- Often poor decisions were made to invest in projects drive by timescale needs of incentives
- It has led to many projects being developed which are simply 'staged combustion units', raising steam to produce power significantly less efficiently than conventional combustion facilities. Furthermore, the 'producer gas' at the intermediary stage is not of sufficient quality for upgrading to other vectors.

There have been two benefits of this approach:

- Over the last 2 years there are now around 70 small scale gasifiers (<200kWe) operating in the UK, typically based on German or Austrian technologies, converting pellets to a basic syngas converted in an engine. This technology would now benefit from being supported under the FIT rather than the unwieldy CfD for such small projects.
- There are now some larger gasifiers under construction which may provide references for elements of the gasification processes at scale, even if they are not providing true syngas.

To drive the benefits identified, it is critical that high quality gasification output is 'pulled', ie appropriate support for heat and transport fuels, rather than the convoluted CfD approach. Our policy recommendations would be:

- Stop supporting gasification and other ACTs via power under the CfD. This is diverting valuable resource to the wrong sector, and leading to confused technology development. The projects in train are more than sufficient to provide as much learning/reference as is relevant.
- The RHI is now irrelevant for any project going forward as the scheme will close before any gasification project can be built. It is critical that targeted support for low carbon heat is put in place rapidly, at least until the societal cost of carbon is fully internalised. Policy is required this year in order to minimise the hiatus during which nothing will be built. It is worth noting that the RHI supported BioSNG, but only on a par with AD, despite the fact that AD is a mature and smaller scale technology. Any new policy needs to recognise this.
- Allow the recently introduced Development fuel RTFC system to stabilise; don't change it.
- Retain the duty differential between renewable gas and conventional fuels for transport; removing this at this current juncture would be highly counterproductive, and is a valuable tool to pull fleet owners into the gas market.

24. Bioenergy with Carbon Capture and Storage (BECCS) has been identified as a key potential mechanism for achieving the UK's 2050 carbon target due to the 'negative emissions' it could offer.

a) What are the potential timescales for commercial deployment of BECCS technologies?

- Approximately 0.5 million tonnes of BioCO_2 is captured per annum in the UK today. Every biomethane grid injection plant strips out CO_2 prior to dispatch. From the response to Q15 and Q23, providing that biomass is not simply burned, but is converted to valuable vectors such as biomethane, BioSNG or BioH_2, capture of CO_2 is completely standard chemicals processing technology; the CO_2 removal is inherent in making the product. Therefore, BioCO_2 capture is NOT a technical or commercial limitation, and could be delivered today.
- The constraint is the transport and storage infrastructure. Realistically such infrastructure will initially be developed for fossil based sources, due to scale. Deployment of CCS in the 2020s is vital to meet the requirement for widespread use of CCS in the early 2030s. This is dependent on government policy, with projects such as the North West hydrogen cluster (https://cadentgas.com/About-us/Innovation/Projects/Liverpool-Manchester-Hydrogen-Cluster) well placed to deliver on this timeframe with HMG support.
- Therefore, BioCCS could realistically be deployed during the 2020s.

b) What are likely to be the optimal uses of BECCS (e.g. electricity generation, hydrogen production)?

As described fully in Q15, bioenergy and BECCS should be focused on conversion to other vectors such as biomethane, BioSNG and ultimately bio hydrogen.

- These approaches provide captured CO_2 as an inherent part of the process; ie at no additional efficiency or cost penalty using totally established technologies.
- These approaches also provide best utility of the biomass resource.
- By comparison, combustion to electricity requires capture of CO_2 from dilute atmospheric streams imposing a significant energy penalty for capture and relies on technologies with limited track record of operation at scale on such dilute streams.

Whilst some may be concerned that capture from biomethane/SNG still leaves some carbon uncaptured, it should be noted that greater than 50% is still being captured at no energy penalty, whilst providing a vector which is completely fungible with a dominant fuel in our current energy system. Furthermore, these technologies are pathways to delivery of biohydrogen (eg a BioSNG plant could easily be converted to BioH_2 if the market changed), where 100% of the carbon could be captured, again at no additional penalty.

c) What efficiencies and costs are possible?

For production of biohydrogen and BioSNG, the efficiencies and costs are provided in:

http://gogreengas.com/wp-content/uploads/2015/11/Biohydrogen-Cadent-Project-Report-FINAL-3.pdf

d) How will performance and cost differ according to feedstock type? What are likely to be the optimal feedstock types for BECCS? What are the implications for domestic supply vs imports (e.g. feasibility, considerations in scaling up over time)?

- As per the response to Q23 (b). There is no fundamental difference between the ability to process different feedstocks; it is more about the resource availability and cost.
- Given internal accounting methodologies, it would make sense to focus on indigenous biomass resource. Given this is a crowded island, waste is therefore a key element.
- It is noted that Facilities such as Drax have established large scale sustainable bioenergy supply chains. At the end of the RO period, these could easily be directed towards alternative vectors and BECCS, probably at portside facilities to optimise feedstock and CCS aspects. However, as the Biogenic CO_2 capture of these imported feedstock takes place in country of origin, there would be accounting rules to address.

e) What are the main barriers and uncertainties associated with the development, deployment and use of BECCS?

- Transport and storage infrastructure. This is not a technical issue, but requires a policy decision to support its development. Projects such as the North West Industry cluster provide a low capital cost routemap to establishment, subject to government policy.
- Accounting treatment of BioCO_2. Currently it is not included within the EU-ETS, and so negative emissions cannot be ‘credited per se.
- Furthermore, there are some more subtle issues associated with transboundary biomass that would need to be considered addressed. Climate change is an international issue, so policy needs to be joined up.

f) What are the risks associated with the pursuit of BECCS that go beyond the risks that relate to supplying sustainable feedstocks and CCS more generally? How can these be managed?

- The risks are dominated by the policy/commercial barriers to CCS.
- With that risk overcome, there is clear evidence that (a) sustainable biomass supply chains can be established, such as Drax and (b) that BioCO_2 can be captured, - ie the 0.5Million tonnes currently being captured.

25. Once developed BECCS is a technology that could be deployed in many different countries around the world. What principles and mechanisms should be used to determine where BECCS is deployed and how any associated negative emissions are accounted for? Should any UK participation in any international BECCS scheme be counted as additional to efforts to meet domestic carbon budgets?

Strategic UK opportunity: The UK is ideally placed to develop CCS – we have billions of tonnes of CO_2 storage around the UK waters. Coastally located conversion plants with capture can deliver CO_2 offshore, and energy vectors such as BioSNG or Biohydrogen through onshore networks. Additionally, the UK has established some of the world's largest international biomass supply chains. Therefore, the UK should be leading the way in BECCS.

International carbon accounting is complex; given that the biocarbon capture benefit from growth is credited in the country of origin, this means that to credit the negative emissions elsewhere would require realignment of international frameworks.

However, even for domestic resources, the current framework does not allow for negative emissions to be credited. This needs addressing.

26. There is currently substantial interest in the development of 'advanced' biofuels for use in sectors such as aviation, shipping and/or heavy duty transport.

a) What are the most promising technologies/processes for advanced biofuel production up to 2050? Please provide details on each technology/process including advantages/disadvantages, timescales for commercial deployment, feedstock type, fuel type and end-user.

For heavy duty transport, biomethane including BioSNG provides a deliverable solution:

- It is a drop-in fuel for CNG vehicles up to 100%
- It is being delivered today – with a filling station network being develop and fleets being converted
- It provides reliable air quality benefits over diesel alternatives
- It provides noise benefits
- It exploits a world leading gas network
- It can be developed and supplied indigenously rather than relying on import of international liquid biofuels, which currently represents a multi-million transfer of value.

Furthermore, development of BioSNG facilities establishes gasification technologies which are suitable for liquid biofuels should that become a requirement, eg for aviation.

Biohydrogen could also be produced, if anything more simply than BioSNG, so could provide an advanced biofuels for eg buses. From waste resources, this is significantly more cost effective than hydrogen from electrolysis.

See Q23, and elements of Q24 for responses to Q26(b)-(g)

27. In 2015 the Government published the Industrial Decarbonisation and Energy Efficiency Roadmaps to 2050. These Roadmaps explored decarbonisation options across multiple industrial sectors and the estimated deployment potential, timescales, cost data and abatement for each option (including bioenergy). Are there any substantial changes from these estimates that the CCC should consider when assessing abatement options in industry? If so please provide your reasoning and details of any recent evidence that relates to these changes.

Biomass can provide a solution for industry. Typically, this is considered to be direct use of biomass (ie combustion for raising steam) or potentially via syngas.

From the responses to Q15/Q23/Q24/Q26, it is argued that conversion to a *fungible* vector such as biomethane/BioSNG provides a much more readily adoptable solution for industry which is a drop in for the natural gas it uses today. The costs for this are found in http://gogreengas.com/wp-content/uploads/2017/03/P167-BioSNG-Commercial.pdf

Furthermore, bioenergy could be used to augment a transition to hydrogen for industry. The Northwest hydrogen cluster is an example of this: https://cadentgas.com/About-us/Innovation/Projects/Liverpool-Manchester-Hydrogen-Cluster

Biohydrogen could readily fulfil this demand, with the benefit of significantly negative emissions when linked to CCS infrastructure. The costs for biohydrogen can be found: http://gogreengas.com/wp-content/uploads/2015/11/Biohydrogen-Cadent-Project-Report-FINAL-3.pdf

28. In our 2011 review we identified wood in construction as a potentially effective method of CCS and a high priority 'non-energy' use in our best-use hierarchy.

Biomass provides a carbon-based material, either for direct use or potentially conversion to other materials via C1 chemistry. If use of biomass in this way genuinely (a) avoids carbon intensive alternatives which lead to fossil emissions and (b) stores carbon over a material timeframe, then clearly this is an important role.

In evaluating this role it is important (a) just like any other vector to fully account for the sustainability of use (this is not something we are currently qualified to comment on) and (b) recognise that in its raw form only a subset of biomass is suitable.

Most biomass is *not* suitable in its raw form for construction; production of construction biomass will itself lead to rejection of significant quantities of biomass which is NOT suitable. The types of assessment of resource undertaken in the bioenergy review referred in Q14 rightly focuses on only the resources not suitable for this use.

29. There are also a number of other potential non-energy uses of bio-feedstocks including bio-based plastics and bio-based chemicals.

Development of bioenergy pathways via gasification such as BioSNG provide a platform for development of any materials based on C1 chemistry. Currently, policy tends to be focused on energy; this provides the vehicle to establish these technologies.

Thereafter, production of biomaterials could be used to avoid additional fossil extraction. This will require a systems view. As biomass is a constrained resource, then careful consideration needs to be given as to where it is best used.