Review of Bioenergy Potential: Summary Report

For Cadent Gas Ltd

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Strategic thinking in sustainable energy

Disclaimer

Bioenergy Market Review

For Cadent

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Scope of work of Anthesis and E4tech: Anthesis was responsible for collating this report and carried out the analysis on municipal, commercial and industrial waste streams. E4tech carried out the analysis on agricultural and forestry residues and energy crops.

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The company combines the reach of big consultancies with the deep expertise of the boutiques. We take our name from the Greek word “anthesis”, the stage of a plant’s lifecycle when it is most productive. Sustainability is now at that exciting stage of flourishing; it has grown up and grown into the mainstream.

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1. Background and Objectives

On behalf of Cadent Gas ('Cadent'), Anthesis, in partnership with E4tech, is pleased to present this review of the UK Bioenergy Market. The objective of the study is to provide a critical appraisal and update of the estimates of the bioenergy potential from waste and non-waste feedstocks, published in a 2011 report by the Committee on Climate Change (CCC)[1].

In view of the objective to decarbonise the natural gas distribution grid, of which Cadent is one of six operators[2], the bioenergy potential forecast in this study is converted into renewable gas potential. This takes the form of biomethane from anaerobic digestion (AD) and bio-Substitute Natural Gas (bioSNG) from gasification.[3]

This Summary Report provides an overview of the methodology and the main results from the study along with presenting the key messages. A Technical Report (of the same name)[4], also undertaken by Anthesis and E4tech on behalf of Cadent, provides detailed information on the assumptions used in the models which underpin the results presented here.

2. Scope and Methodology

The approach used to model bioenergy potential necessarily varies between waste and non-waste feedstocks, for which the methodologies are set out in Sections 3 and 4 respectively. However,
Figure 1 presents the general methodology followed in this study for both types of feedstocks. The blue boxes in
Figure 1 refer to the review of the CCC report, the dashed boxes reflect the tasks undertaken for each feedstock and the orange fill boxes represent the outputs from this study.

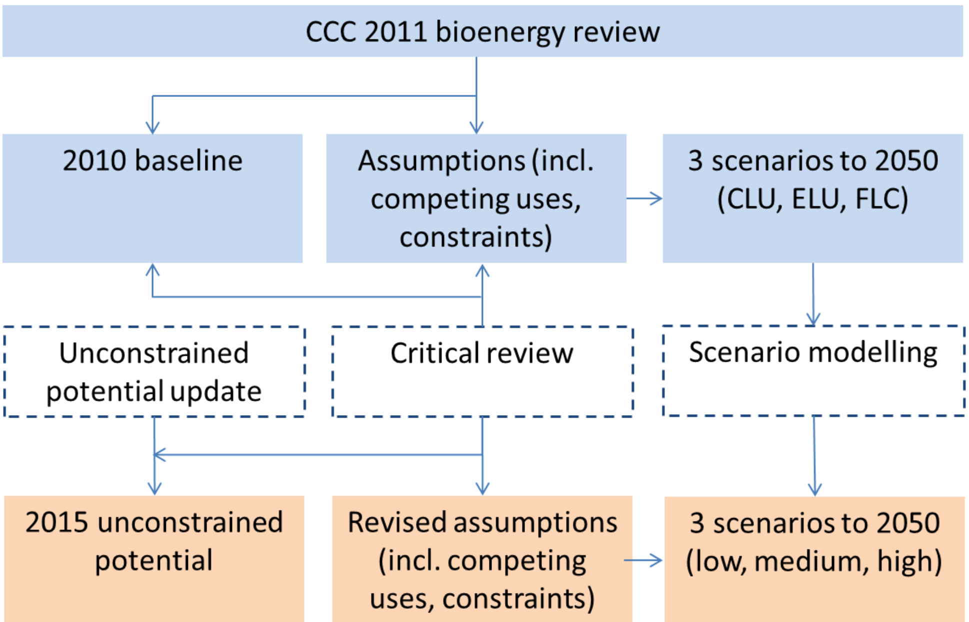

Figure 1: Methodology

[1] CCC (2011), *Bioenergy review*, December 2011. Available at www.theccc.org.uk/publication/bioenergy-review/

[2] See http://www2.nationalgrid.com/UK/Our-company/Gas/Gas-Distribution-Network/

[3] Bio-SNG is also sometimes known as 'bio-Synthetic Natural Gas'

[4] See www.tobeconfirmed.com

A key component of the study is the critical review of the CCC report. The goal of this was to understand where the data was derived from as well as the assumptions upon which the scenario modelling, and the scenarios themselves, were built. Using the latest available data, an updated unconstrained feedstock potential for 2015 was then established. This revised data, together with the critical review, was then used as the basis for building three updated scenarios (high, medium/central and low) to forecast bioenergy potential across all the feedstocks to 2050.

As a principle, this study aims to quantify 'technical potential', which can be defined as: *the quantity (and related energy content) of biomass, which does not have competing uses and, in the case of wastes, is not required to meet national recycling targets.*

2.1 Waste Feedstocks

The waste feedstocks included within the scope of the study are those sourced from:

- Local authority collected waste (LACW), or what was previously known as municipal solid waste (MSW), which includes wastes collected from households and from some businesses;
- Commercial & Industrial waste (C&I):
    - Commercial wastes similar in composition to LACW wastes, but which are collected from businesses and sit outside of the LACW stream; and
    - Industrial wastes collected from businesses, which also sit outside the LACW stream, but are not similar in composition.
- Construction and demolition (C&D) wastes, which are predominantly inert, but also contain significant fractions of wood; and
- Sewage sludge from waste water treatment.

Relevant waste types from these sources, along with routes to biomethane and bio-SNG generation, are presented in Figure 2. Commentary is provided in the technical report for tallow and used-cooking oil as waste feedstocks, but these are not included in the modelling of bioenergy potential.

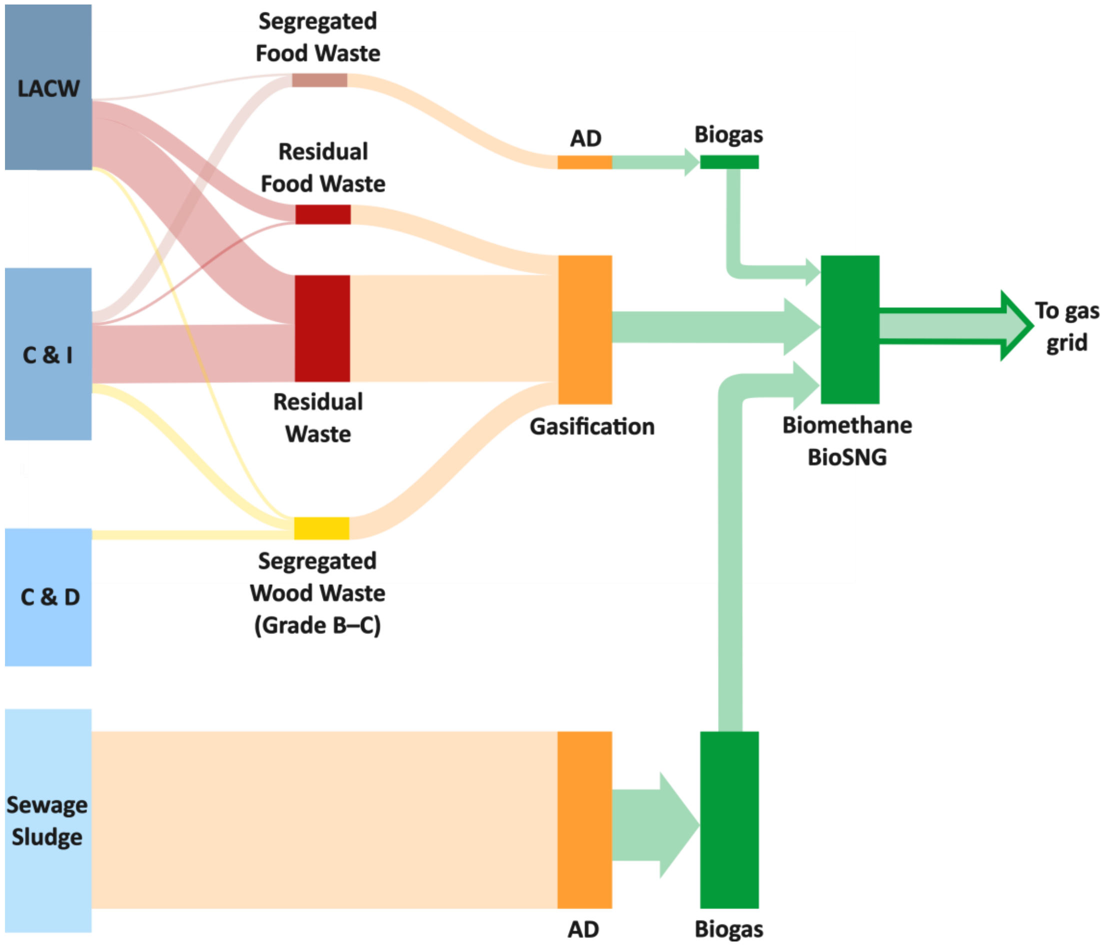

Figure 2: Waste feedstock sources and renewable gas routes relevant to this study[5]

For the waste flow models developed, a baseline "unconstrained" waste arising for each material stream waste was estimated from available public domain data, and waste considered to be processed by competing high value alternative routes (e.g. different forms of recycling) was subtracted to give the baseline "available" waste arisings per material.

For the input data for the model, data sources and market reports made available since the publication of the original CCC report[6] were identified and regulatory authorities in each UK nation were contacted to obtain additional relevant data. These data sources are described further in the Technical Report with an assessment of data confidence for each.

The key assumptions used in developing the forecast model, which drive waste availability to 2050 relate to:

- **Waste arising growth,** which is based on a range of growth rates derived from UK Government population and economic growth estimates. An increase in overall arisings will generally increase the volume of waste available for renewable gas production;
- **Recycling rates,** which are based on the achievement of EU and UK national targets, with additional 'stretch' targets modelled for particular scenarios. Increased recycling rates and diversion to high value markets/applications have the potential to reduce the amount of waste available for renewable gas production;

[5] Not to scale

[6] CCC (2011), *Bioenergy review*, December 2011. Available at www.theccc.org.uk/publication/bioenergy-review/

- **Long-term contracting for residual waste treatment** (for instance for energy recovery), which is assumed not to constrain material from being available for renewable gas production, as all such contracts will expire within the forecast period to 2050; and
- Finally, it is assumed that all **Refuse Derived Fuel** (RDF) currently exported is available for renewable gas production, as again, any long-term contracts will expire before 2050.

The detail behind all the above assumptions is provided in the Technical Report.

2.2 Non-waste Feedstocks

All non-waste biomass feedstocks suitable for biomethane and bioSNG production are included within the scope of the study, and grouped as follows:

- **Dedicated energy crops**, including Miscanthus, Short Rotation Coppice willow & poplar and other non-food perennial crops;
- **Agricultural residues**, including straw, cobs, husks, shells, slurry and manure;
- **Forestry residues,** biomass residues gathered from the forest floor: trimmings, stumps;
- **Arboriculture arisings,** biomass gathered from public green spaces and transport corridors;
- **Short rotation forestry,** woodland that grows at relatively short cycles of between 8 and 20 years;
- **Small round wood,** generated during first pass forestry operations and is defined as branches greater than 7cm and less than 18cm in diameter;
- **Sawmill co-products,** sawdust, shavings and other residues from UK sawmills;
- **Wet animal manures,** slurries generated by cattle, pigs and laying chickens in the UK; and
- **Macro-algae,** seaweed converted into biomethane through anaerobic digestion.

Commentary is provided for other non-waste feedstocks in the Technical Report, but these are not included in the bioenergy potential scenarios. These feedstocks include:

- **Industrial residues**, wine lees, grape marcs, crude glycerine, molasses, brown & black liquor, tall oil and tall oil pitch; and
- **Imported biomass**, including woody biomass and agricultural residues.

The baseline estimates are derived from data gathered from Defra, Forestry Commission, Food and Agricultural Policy Research Institute (FAPRI), National Non-food Crops Centre (NNFCC), the Agriculture and Horticulture Development Board (AHDB) and the Department for Business, Energy and Industrial Strategy (BEIS). These sources also contribute to the development of the scenarios and the assumptions for the projected unconstrained potential, competing uses and other constraints.

Bioenergy potential is determined using:

$$Bioenergy\ potential = (Unconstrained\ potential - Competing\ uses) \times (1 - Constraint\ factor)$$

Unconstrained potential is the total feedstock resource that is available in the UK before any competing uses or constraints are applied. Competing uses refer to non-energy uses of the feedstock, this is separated into price independent which is constant throughout each of the scenarios and price dependent which will vary with the low, medium and high prices available to bioenergy. The constraint factor accounts for technical, market, regulatory and infrastructure factors which can limit the potential of the feedstock.

In order to derive theoretically available feedstock estimates it is important to note that the feedstock potentials developed in this study consider only competing uses outside bioenergy (i.e. competition from biomass heating, power plants or biofuels is not considered). Further research is required to understand the indirect environmental impacts of diverting feedstocks from competing non-energy uses.

3. Bioenergy and Renewable Gas Potential

3.1 Bioenergy Potential

3.1.1 Waste Feedstocks

Figure 3 shows that converting forecast arisings of waste feedstocks into bioenergy potential results in a total of 73 TWh/annum of bioenergy potential under the central (medium) scenario, with a relatively narrow range of uncertainty from **64 - 77 TWh** for the low and high scenarios. Residual and wood wastes are the largest contributors. Total bioenergy potential falls gradually to 2030, as the effect of recycling growth outweighs the impacts of waste growth. However, as recycling slows from 2030, the net effect of these two factors is an annual increase in bioenergy potential to 2050.

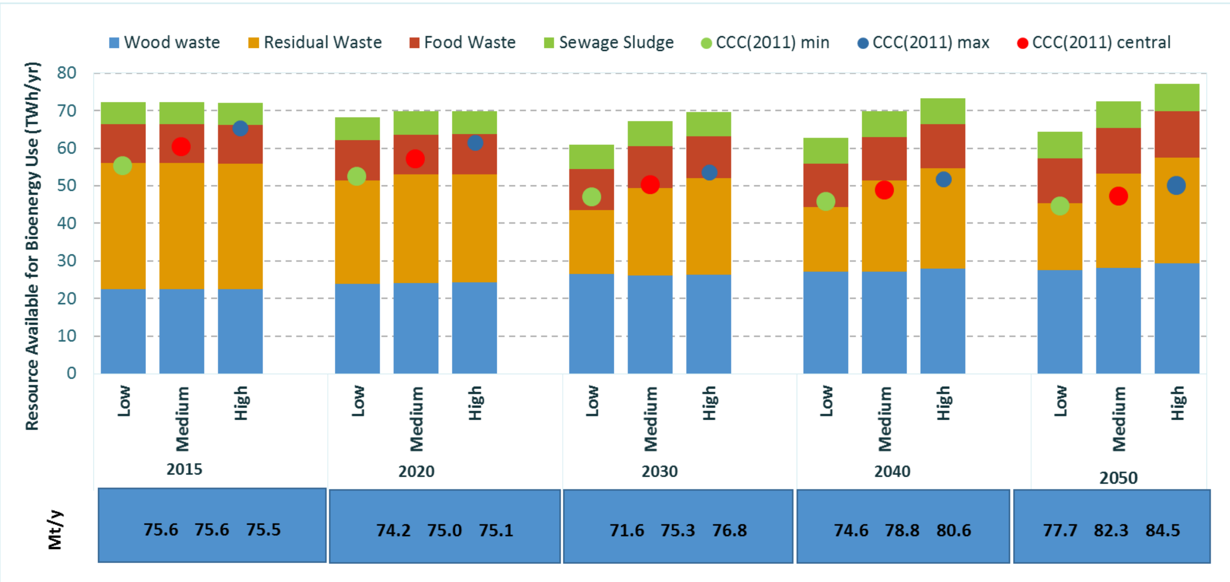

Figure 3 : Waste resources available for bioenergy use, including CCC, to 2050

Figure 3 shows that the bioenergy potential estimates are above those of the CCC, particularly in the later years of analysis. This is the result of:

- Higher, albeit still relatively conservative, growth rates used for LACW and C&I wastes, compared with those used by the CCC, which at the time reflected the slow-down in waste growth resulting from the financial crisis;
- The CCC study not applying any growth forecasts or any changes in relation to increased segregation and recycling of waste wood. Such forecasts are included in this study;
- The use of, in this study, more up-to-date primary data for food wastes relating to the baseline and the inclusion of the impact of population and economic growth, which is omitted in the CCC analysis;
- The assumption, in this study, that residual waste being sent to landfill is available for generation of bioenergy; and

- The result of new data being used in this study in relation to the baseline arisings of sewage sludge, which was not available at the time of the CCC study.

3.1.2 Non-waste Feedstocks

The modelling of non-waste feedstocks, as presented in Figure 4, results in a central (medium) estimate of 76 TWh of bioenergy potential in 2050, with a large degree of uncertainty demonstrated by the 30 -173 TWh range between the low and high estimates. Energy crops are the largest contributor in terms of potential as well as uncertainty. Scaling the energy crops industry is challenging and expensive, awareness amongst farmers and land owners remains low, and dedicated policy support would be critical for the industry to realise its potential.

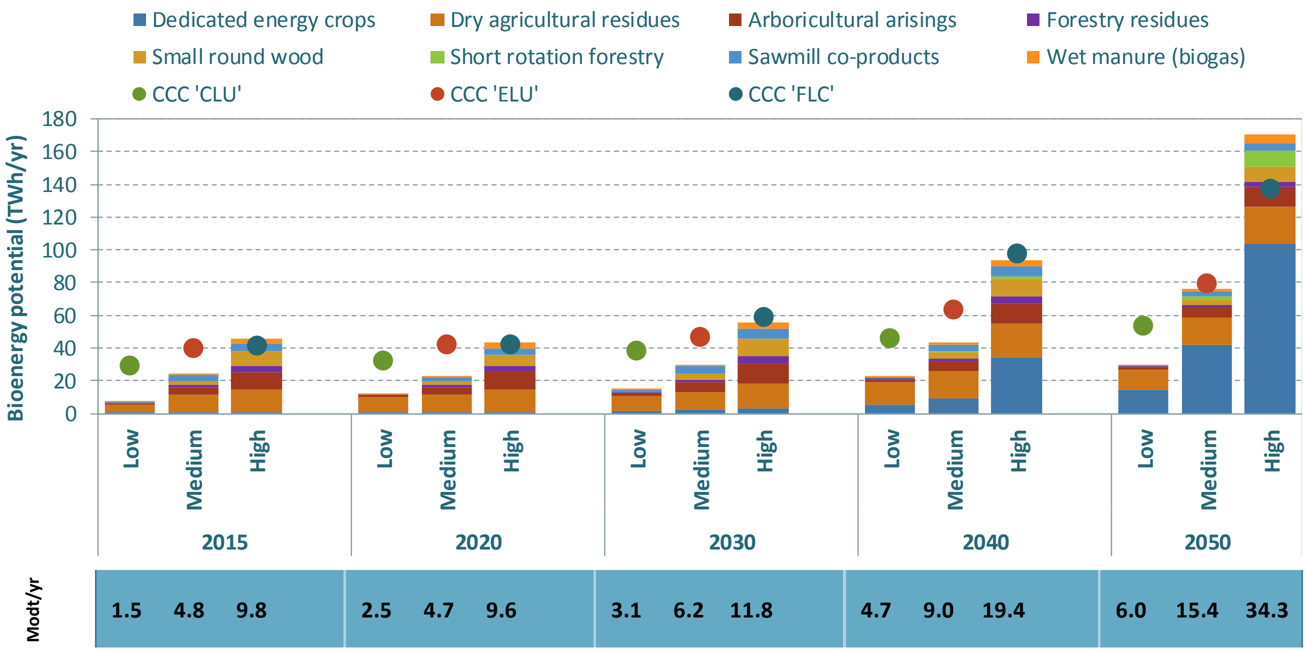

Figure 4: Non waste bioenergy potential for each scenario, including CCC, to 2050

The bioenergy potential estimates are lower than those of the CCC, particularly in the early years of analysis. This is the result of:

- The potential of **dry agricultural residues** being driven primarily by straw availability, which depends on competing uses and straw incorporation rates. The bioenergy potential estimate in this study is significantly lower than the CCC's estimate because of updated demand data and a new assumption over minimum soil incorporation rates;
- Similar to other forest related resources, the potential of **small round wood** is dependent on the standing volumes of the UK's forests. The potential is lower in comparison to the CCC because of new assumptions used by Forest Research for the unconstrained potential and an emphasis on carbon sequestration to meet climate targets instead of bioenergy production;
- The potential for **arboricultural arisings** is unlikely to change significantly to 2050 and its highly dispersed nature poses problems for collection and processing. Whilst the CCC assumed no competing uses, this study accounts for arisings being converted to compost as mulch or being left in place after cutting (due to economics); and
- The potential of **wet manure** for bioenergy is regional, and highly dependent on cost-effective supply chains to collect the highly dispersed and very wet manures – many resources will be too far from viably-

sized AD plants. CCC assumed that a large share of this feedstock, currently spread to land as a fertiliser, could go to AD before the digestate was returned to the land – however, more recent estimates only assume a limited share of the feedstock is viable to collect.

3.2 Total Bioenergy Potential

Based on the revised assumptions for feedstock arisings, the modelling undertaken for this study results in a total estimated bioenergy potential of 149 TWh in 2050 for the medium scenario, ranging from 94 to 250 TWh under the low and high scenarios, as presented in Figure 5.

Under the medium assumptions (ELU for the CCC), the total bioenergy potential estimates are lower than those in the CCC report for the period 2020-2040. This is largely the result of lower estimates for non-waste feedstocks (for the reasons explained above) offsetting the slightly higher estimates (than those of the CCC) for waste feedstocks. In 2050, however, the estimate of total bioenergy potential is very similar to that of the CCC. As explained above, this is as a consequence of a potential significant uplift in energy crops, albeit this depends upon long-term policy initiatives and investment support.

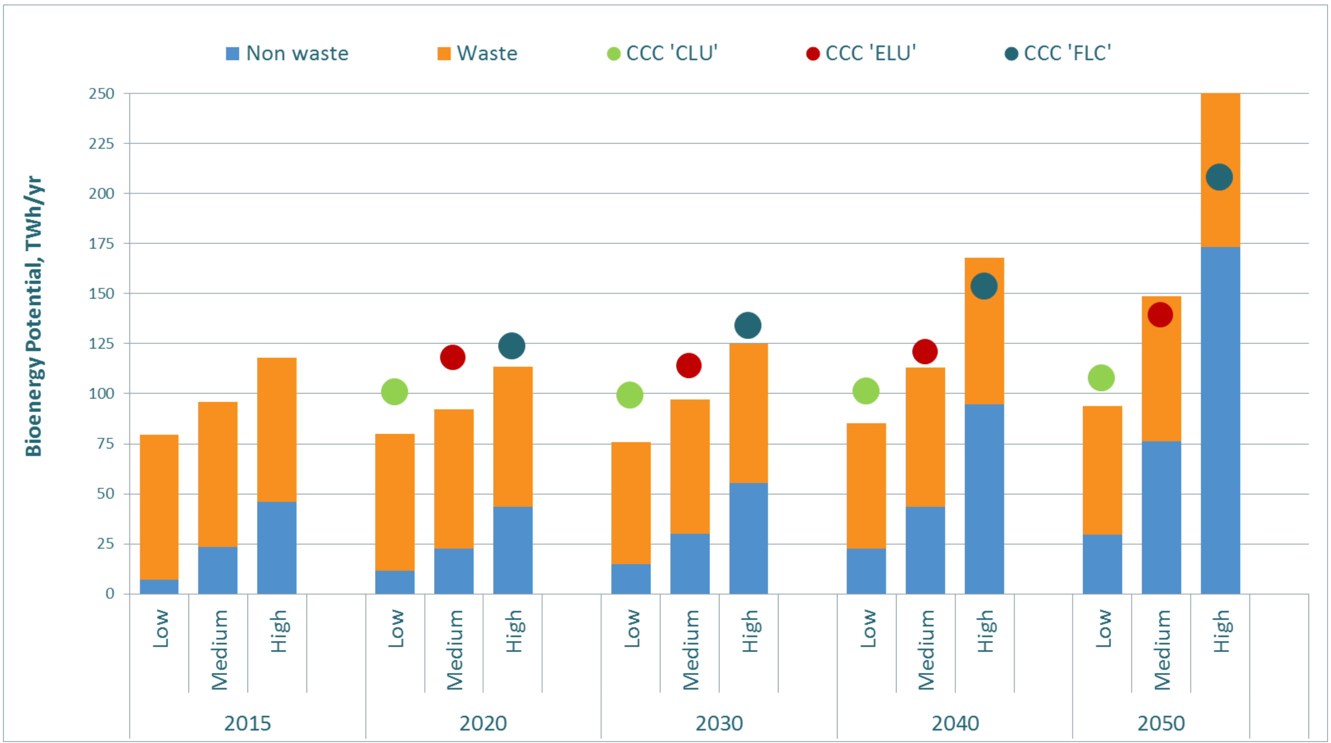

Figure 5: Bioenergy potential for each scenario, including CCC, to 2050

3.3 Renewable Gas Potential

The forecast total bioenergy potential presented above has been converted into renewable gas potential, which results in a total renewable gas potential of around 108 TWh/annum in 2050 under the central scenario, as shown in Figure 6. Modelling of low and high scenarios results in a range of uncertainty of 68–183 TWh in 2050.

- 47-56 TWh from **waste feedstocks**, with 83% of this coming from bioSNG and 17% from biomethane via AD. It should be noted that whilst the balance of the split between biomethane from AD and bioSNG may vary over time, this change is unlikely to be sufficient to significantly change the total level of renewable gas generation; and

- 21-127 TWh from **non-waste feedstock,** with 97% of this coming energy crops, short rotation forestry and wood/forestry residues converted to bioSNG and the remaining 3% from biomethane via anaerobic digestion of wet manures and macro-algae.

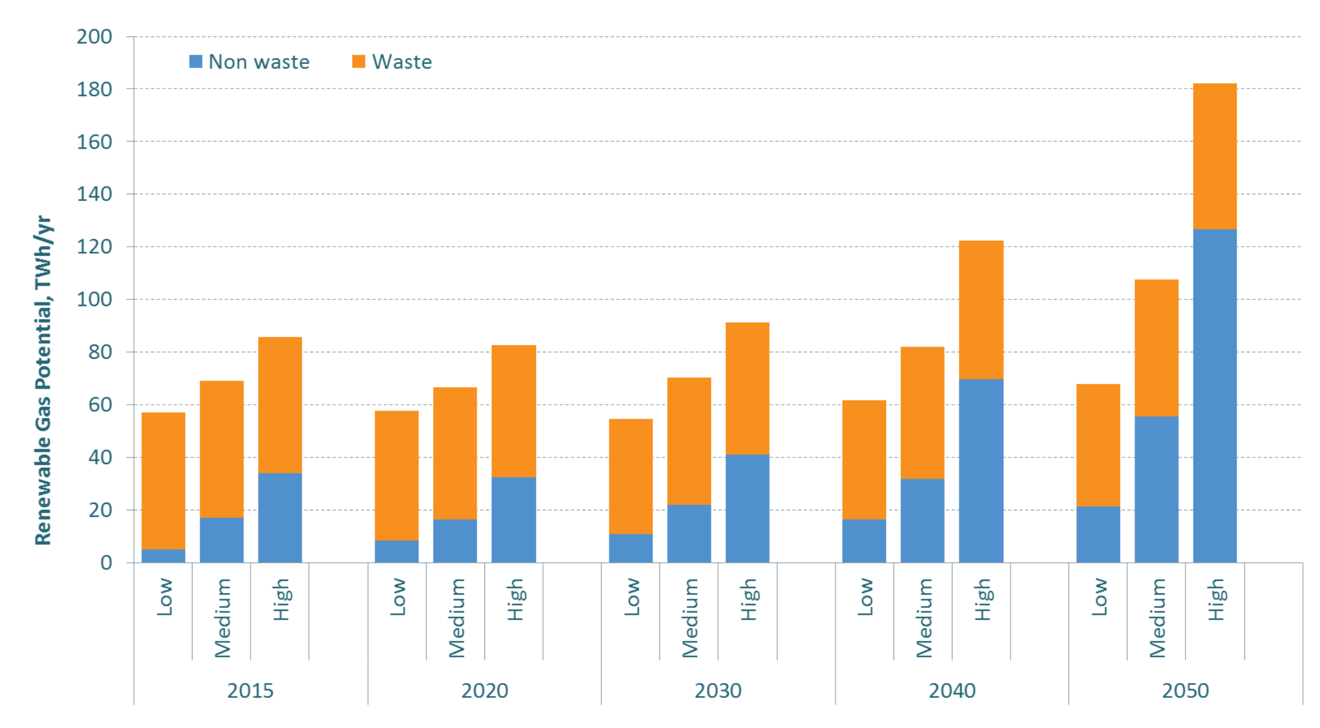

Figure 6: Renewable gas potential 2015 to 2050

4. Summary of Key Messages

The key messages which can be drawn from this study can be summarised as follows:

- A range of more up-to-date data and related new assumptions have been employed for this study, but the results for total bioenergy potential in 2050 are broadly similar to those modelled by the CCC in 2011:
    - In the early years, the lower estimates of bioenergy potential in this study are primarily the result of a lack of progress in respect of planting of energy crops since 2011.
- This work suggests that biomethane will continue to make an important contribution to renewable gas generation, but suggests that BioSNG has far greater potential through its greater versatility in respect of the range of feedstocks which might be processed (once the technology has been demonstrated at commercial scale);
- Bioenergy, and in particular renewable gas, can make a significant contribution to meeting 2050 climate change targets, in particular when supporting decarbonisation of the heat and transport sectors, which are currently lagging behind the electricity sector;
- To further enhance the evidence base for policy-making in this area, Government should:
    - Support the collection and assimilation of improved data for many feedstocks, in particular for C&I wastes and C&D wastes, to enable more detailed analysis of the local and regional potential for the production of renewable gas and the efficient use of these feedstocks; and
    - Continue to support development of best practices and improved sustainability frameworks, which will improve the understanding of potentials from agricultural and forestry residues, energy crops and short rotation forestry, and will provide assurance around their sustainable use.