The potential for Renewable Gas in the UK

A paper by National Grid

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Executive Summary

Renewable gas has the potential to make a significant contribution to the UK's renewable energy and carbon reduction targets for 2020. And in the longer term, with the right government policies in place, renewable gas could meet up to 50% of UK residential gas demand. Produced mainly via a process of anaerobic digestion (AD) or thermal gasification of the UK's biodegradeable waste, renewable gas represents a readily implementable solution for delivering renewable heat to homes in the UK. Renewable gas can also deliver greater security of energy supply for the country as well as a solution for waste management as UK landfill capacity declines.

In terms of the cost to the UK of delivering renewable gas, it is estimated that the marginal cost (i.e. that over and above the cost of the waste infrastructure which must be built anyway in the UK to deal with reducing landfill capacity) would be in the region of £10bn. This cost compares well with the likely cost of delivering other large scale renewables such as wind. The unit cost of renewable gas would be of a similar level to the cost of other sources of renewable energy which are currently supported with subsidies.

There are no insurmountable technical or safety barriers to delivering this solution (the technology is already being deployed in many other countries). The key to delivery is Government policy and regulation. The following policy developments are urgently required:

- A commercial incentive for renewable gas producers to upgrade and grid-inject their gas rather than generate electricity which is currently incentivised under the RO scheme despite being a generally much less efficient use of the valuable waste stream;
- A comprehensive waste management policy for the UK to ensure that each waste stream is directed to the most appropriate technology to maximise energy recovery and recycling
- A regulatory framework to provide incentives and to clarify the roles and responsibilities of the gas transporters with respect to renewable gas connections;
- Continued support for R&D in renewable gas production and upgrade technologies.

Renewable gas represents a great opportunity to deliver 'green heat' to the UK. It is a unique, large scale solution which unlike other options such as district heating and heat pumps utilises existing heat infrastructure (i.e. gas grids) already largely paid for by the consumer. So renewable gas does not require consumers to find the money for new heating installations in the home and also avoids the disruptive road works that would be required to build more network infrastructure.

Background

The debate on how to deliver 'green' or renewable heat to UK homes is picking up momentum. However, most of the discussion to date has focussed on the potential for heat-pumps, solar thermal, district heating and biomass boilers. It is well recognised that the energy mix of the future will require a wide range of solutions rather than a single answer. However, the potential for one large-scale solution has been overlooked so far. That is the potential for renewable gas, produced predominantly from waste, to be injected into the gas grid to meet residential heat demand.

Currently, renewable gas production in the form of landfill gas and sewage gas represents a significant proportion of the UK's current renewable energy portfolio. In the region of 1.4bcm (billion cubic meters) of renewable gas are produced in the UK at the moment – which could meet around 1% of total UK gas demand. However, because of the commercial incentives (the Renewable Obligation Scheme), all of this gas is used to generate electricity at efficiency levels of around 30% in most cases. If the gas was to be injected into the gas grid, then this could be delivered straight into consumers' homes and utilised for heating at efficiency rates in excess of 90%. This would in itself more than double the contribution of existing renewable gas sources to the renewables target.

Before renewable gas can be injected into the UK gas network, it must be cleaned or "upgraded" to meet UK gas pipeline specifications. The main purpose of this process is to remove gases such as carbon dioxide and hydrogen sulphide to leave an almost pure (~98%) methane gas. This upgraded gas is often termed biomethane. Renewable gas upgraded to biomethane followed by injection into the gas grid is a technology which is already being deployed in many countries in Europe – including Germany, France and Austria. In the US, National Grid takes landfill gas from the Staten Island landfill and injects the cleaned gas into our New York Grid.

In terms of the technology to produce renewable gas or biomethane, the key ones are anaerobic digestion, which is more suited to producing renewable gas from wet wastes, and gasification – better suited to dry wastes and many energy crops. Anaerobic digestion is not without its challenges but it is a very well established technology which has been used for hundreds of years and is currently used in most sewage works and some waste processing plants in the UK. Gasification technology is less well developed for use on waste – having previously been used in some form for gasifying coal up until the early 1970s. Gasification technology is progressing and developing apace with demonstration plants being built in this country and around the world. The other relevant technology is that required for the gas "clean-up" or "upgrading". Again, this technology is already being used in other countries and the costs of it are falling as new techniques emerge.

The potential for Renewable Gas in the UK

As part of our wider efforts to understand and facilitate the development of the UK's future energy portfolio, National Grid has carried out some analysis to evaluate the potential for renewable gas to contribute to that mix. Ernst & Young were commissioned to provide support with this analysis which considered two different scenarios for 2020. The work considered all of the waste streams for the UK as well as a possible limited contribution from sustainable energy crops.

The "Baseline" scenario considers a world where a significant proportion of waste still goes to landfill, is not sorted appropriately or is still used for electricity generation – rather than being used for renewable gas production. The "Stretch" scenario aims to see what could be achieved with renewable gas if policies are put in place to ensure that all waste is directed towards renewable gas production and that the most appropriate (high yielding) technology is used for each type of waste.

The results of this analysis are illustrated in the table below which sets out the contribution of each of the key waste streams under each of the scenarios:

Potential renewable gas production scenarios - volume of upgraded biomethane

	2020 (baseline) million m^3	2002 (stretch) million m^3
Sewage / waste water	270	629
Manure - dairy and cattle	254	507
Agricultural waste	234	967
Food waste	729	1,333
Biodegradable waste	1,042	8,328
Wood waste	1,253	2,697
Miscanthus	1,845	3,971
Total	**5,625**	**18,432**
As % total UK gas demand (~97bcm)	**5%**	**18%**
As % residential gas demand (~35bcm)	**15%**	**48%**

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As the table highlights, current UK total gas demand is around 97bcm (billion cubic metres) and residential demand around 35bcm. So our figures suggest that renewable gas could contribute in the region of 5% to 18% of total UK gas demand. And in a future world where much of our electricity needs may be met by renewable generation such as wind rather than gas generation, what is even more interesting is the proportion of residential (heat) demand that renewable gas could satisfy. The figures above indicate that up to 50% of residential gas demand could be met with renewable gas in the "Stretch" scenario.

Furthermore, as a proportion of the UK's total energy demand, 18bcm of renewable gas would represent in the region of 10% of that total – meaning that renewable gas could deliver up to two thirds of the UK renewable energy target of 15% by 2020.

The stretch scenario should be seen as a "technical potential" figure which would require every person and every business in the country to sort and direct their waste appropriately. Clearly, this would be a significant challenge, but it is important to highlight the major impact that renewable gas could have with the right policies and therefore draw attention to the fact that if even just a half, or a quarter of this potential were realised, then this would still have a very positive impact on the achievability of the UK's environmental goals and climate change targets.

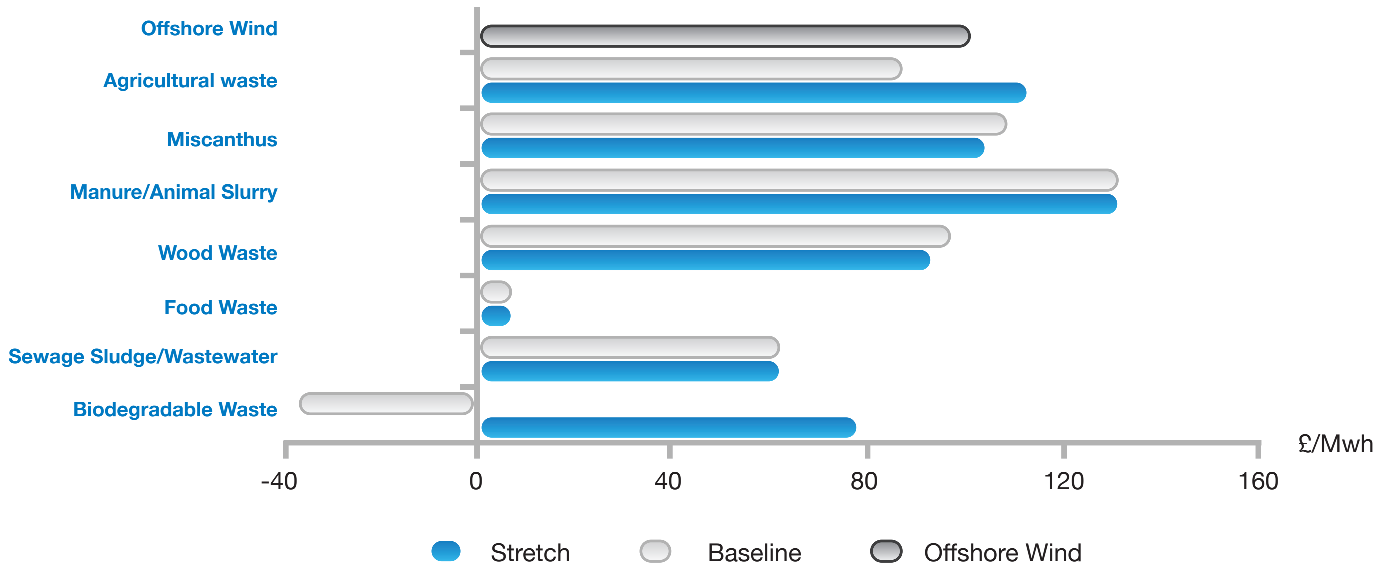
The economics

In terms of the total cost to the UK economy, it is estimated that the capex required to deliver the "stretch" scenario would be in the region of £30bn. However, a significant proportion of this (around £20bn) relates to the cost of waste infrastructure which needs to be built anyway, because of a diminishing landfill capacity, and is effectively therefore a 'sunk cost' to the UK. So the relevant figure to consider is the marginal cost of the infrastructure required to upgrade and inject the renewable gas into the gas grid – which is estimated to be something in the region of £10bn. Given that this could deliver two thirds of the 2020 renewables target, this cost compares very well with the likely costs of delivering other large scale renewables such as wind.

The analysis indicates that the cost of producing and injecting a unit of pipeline quality renewable gas is, at an average of around £100/Mwh, of the same order as the cost of energy from other RO supported renewable sources. By way of comparison for example, the cost of off-shore wind can be approximated by looking at the cost of buying wind generated electricity which is around £100/Mwh (assuming 1.5 ROCs at £35 each and £65/Mwh "brown" electricity price).

This figure for renewable gas includes the cost of production, upgrade and injection. In the case of food waste and biodegradeable waste this cost may be brought down considerably if it is assumed that a "gate fee" is charged for processing the waste – that is, the renewable gas producers can get an income stream for taking the waste away. This is illustrated in the chart below where a gate fee has been assumed for these two waste streams:

Cost of Renewable Gas Energy - comparison with Offshore Wind



Even if a gate fee is not assumed, the costs for food and biodegradeable waste sourced renewable gas fall within the range of the other categories.

However, in a sense, the comparison with offshore wind, illustrated above, is not a like-for-like comparison because renewable gas represents a unique solution for delivering "green" heat in the UK – a solution that renewable electricity or heat pumps cannot provide without significant additional electricity grid infrastructure investment – particularly at a distribution (low voltage) level. The cost of this additional electricity grid infrastructure required to heat homes using renewable electricity must be added to the cost of wind generated electricity to provide a true comparison. This study has not considered this additional electricity infrastructure cost in any level of detail however an approximation may be obtained by assuming that 25% of the low voltage electricity distribution networks (~300,000km) is replaced at a cost of around £100k per km. This would give a network infrastructure cost of just under £10bn which is of the same order as the **total** cost of the renewable gas solution (as per above).

Carbon abatement cost

The analysis also considered the cost of carbon abatement with renewable gas – and how that compares with other sources of renewable energy. This indicates that on average, the cost of carbon abatement by displacing natural gas with renewable gas is greater than for displacing "brown" electricity with for example wind. This is because if a unit of "brown" electricity (such as that derived from coal) is displaced by a unit of renewable electricity e.g. wind, then a very carbon intense fuel is displaced by a clean substitute. However, when a unit of natural gas is displaced by a unit of renewable gas then a comparatively 'cleaner' or low carbon fuel is substituted. Consequently, more units of natural gas need to be displaced for the same degree of carbon abatement than would be the case for renewable electricity.

However, as argued above, this is again not really a like-for-like comparison. To make a true comparison, the cost of the additional electricity grid infrastructure should be added to the cost of carbon abatement using renewable electricity.

Conclusion on economics

The analysis indicates that the cost of delivering renewable gas to UK homes is likely to compare very favourably with other proposed solutions for heat such as retrofitting heat pumps or storage heaters to existing homes on the gas grid. Furthermore, although the cost of carbon abatement with renewable gas maybe slightly higher, it must be noted that renewable gas represents a unique solution for heat in the UK - a solution that electricity cannot provide without significant additional and disruptive electricity grid infrastructure investment.

The benefits of renewable gas for the UK

Not only does renewable gas present a great solution for delivery of large-scale renewable heat in the UK, it also addresses the escalating issues of energy security of supply and waste management.

A solution for heat

As mentioned above, renewable gas being upgraded to biomethane and injected into the UK gas distribution network represents a unique opportunity for the UK to address the issue of renewable heat with a single, large scale solution. Renewable gas can be delivered using existing gas distribution infrastructure. This infrastructure has already been largely paid for by the consumer and is currently being modernised to make it safer and 'greener'. Compared to most other countries this network has a very dense coverage in many parts of the UK which makes it very accessible for biomethane injection and creates advantages over other technologies.

For example, the street-works required to construct district heating networks, in pursuit of bringing lower carbon heat to existing premises is likely to cause major disruption. In contrast, because most houses have systems set up to be heated with gas, there will be no requirement for consumers to have work done in their homes, to have to find capital for new appliances or to be inconvenienced in any way to deliver renewable gas. One other option which is seen as a potential solution for "green heat" is biomass for use in special biomass boilers. However, the logistics associated with transporting and storing such large quantities of biomass to consumers' premises would be significant. Gasification of this biomass at a few central locations, with injection of the gas into the grid would remove these logistical issues. As such, renewable gas represents a simple solution for the grid-connected consumer – compared to all other alternatives for renewable heat. It is also a solution that avoids the complex issue for the government of developing and delivering incentives to drive consumers into action.

This study recognises that there will be certain geographies and locations for which alternative solutions to renewable gas such as heat pumps or district heating are likely to be preferable. For example, off-gas grid houses or new builds are likely to be good candidates for the alternative solutions. However retrofitting existing houses which are on the gas grid with alternative heat solutions will be costly and time consuming in comparison with renewable gas. And as we look forward to 2050, it is important to recognise that delivering 80% emissions reductions is going to require a very sizeable contribution from heat which only renewable gas is able to deliver without significant inconvenience to consumers and other residents of the UK.

A solution for managing waste

Regardless of whether biomethane injection is introduced in the UK, the country will need to make a significant investment in waste infrastructure to deal with the declining landfill capacity. Anaerobic Digestion (AD) and gasification are both good alternatives for treating waste. AD, which is more established, is an enclosed process of which the by-product (other than renewable gas) is a very high quality fertiliser which could be used on UK land and which would reduce imports of fertiliser into the UK. Although gasification is a less established technology, it is preferable to incineration from an emissions perspective. This means that both AD and gasification do not face the same kind of environmental, air pollution issues as incineration which is the main alternative for processing waste as landfill capacity declines.

Energy security of supply benefits

Renewable gas production in the UK would mean that this country would continue to have an indigenous supply of gas on which it could rely as North Sea reserves run down. Furthermore, the renewable gas solution creates the possibility of importing biomass for gasification, increasing diversity and thus security of supply. Finally, renewable gas has a significant advantage over almost all other sources of renewable energy in that it can be easily stored – either in the form of gas, or as a solid biomass (e.g. wood chips).

What does government need to do to deliver renewable gas to the UK?

There are no insurmountable barriers to delivery. Technically, renewable gas production, upgrade and injection is possible and the upgraded gas will be safe to use in consumer appliances provided that the gas meets the UK specifications set out in the Gas Safety (Management) Regulations (GS(M)R) 1996. Typically, renewable gas has a lower calorific value (CV) than natural gas (even when it meets the GS(M)R) which means that some consumers downstream of a biomethane injection plant might receive less energy per unit of gas than the average. This is not a technical issue but a commercial, billing issue that may be resolved in the short term by enriching the gas with small quantities of propane. However in the longer term, it should be possible to work with Ofgem to develop a billing regime to reflect the different CVs of different sources of gas.

This study does not however underestimate the effort that will be required on a number of fronts to deliver renewable gas to the UK. The main hurdles to delivery are commercial, policy and regulatory and the following changes are urgently required:

- A commercial subsidy or incentive to level the playing field between renewable gas upgrade and injection and use of renewable gas for electricity generation. The existing Renewable Obligation (RO) scheme ensures that all renewable gas is used to generate electricity, regardless of whether the waste heat is being captured and used, and whether this is the best use of the fuel from a carbon or environmental perspective. The biomethane injection incentive can be delivered through the renewable heat incentive mechanism which the Government recently gave itself powers to develop in the Energy Act 2008. The subsidy should be set at a level to provide enhanced returns to the producer when the renewable gas is used more efficiently by injecting into the gas grid, rather than used for generating electricity.

A major concern is that if this subsidy is not introduced quickly enough, the Local Authorities and other waste producers will enter into long term contracts with companies to incinerate the waste, meaning that the opportunity to convert to renewable gas and gain the associated benefits is missed. DECC have indicated that they are willing to look at interim measures that could be taken to provide bridging funding for producers between now and when the incentive is introduced - this will be key to enabling the UK to grasp the full potential of renewable gas.

- A comprehensive waste policy and regulatory framework is required to ensure that each local authority directs its waste streams towards the most appropriate renewable gas technology and that the waste is appropriately sorted at source to facilitate maximum renewable gas production. As highlighted above, this needs to be done quickly to ensure that Local Authorities which are currently examining waste management programmes do not enter into inefficient electricity generation schemes – e.g. incineration plants where the heat is not captured and utilised.

- The government should continue to fund R&D into AD technology and this should be extended to cover gasification and upgrade technologies to ensure that maximum renewable gas yields are captured from our valuable waste streams. Demonstration plants should be built quickly to jump-start the industry and provide valuable technical and commercial data ahead of the longer term policy changes being made.

- A regulatory framework should be put in place to provide incentives and clarify roles and responsibilities for gas network owners regarding renewable gas injection connections. And in addition to the CV issue mentioned above, the final key regulatory issue that needs to be resolved is the specification in GS(M)R for oxygen content of pipeline gas which is currently too low to include renewable gas. Providing that the gas does not enter the transmission (high-pressure) tier of the gas network, then our initial view is that the higher oxygen content of renewable gas will not cause any technical or safety problems and hence a change to the regulations will enable the large scale roll out of renewable gas. This view is supported by the fact that biomethane injection is already being deployed in several countries in Europe.

All of these hurdles can be resolved within relatively short time scales if there is the will within government and regulators to do so. As highlighted above, the sooner these issues are addressed, the greater the contribution that renewable gas will be able to make to 2020 carbon and renewable targets. Without action now, a great opportunity could be missed.

Disclaimer

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