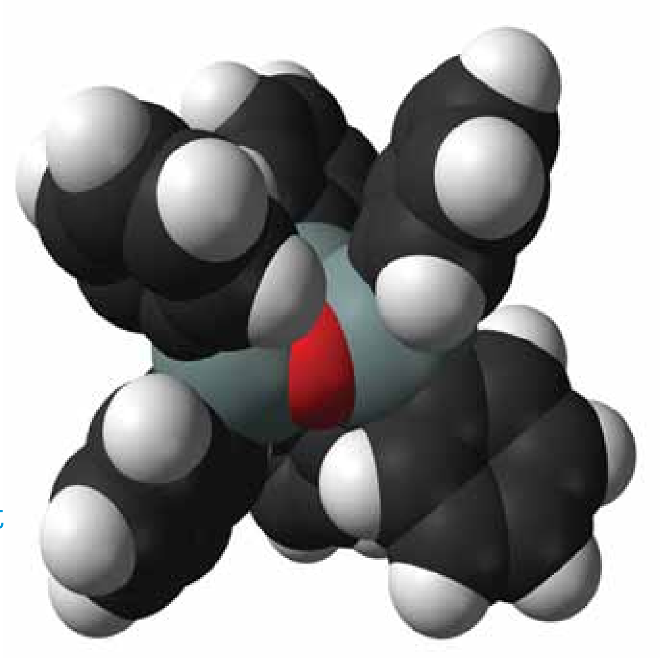
Injecting biomethane into the UK's gas grid: The challenge of siloxanes



Injecting biomethane into the transmission and distribution system represents a major opportunity to demonstrate the long term worth of the gas sector and its accompanying infrastructure in the UK. However, as anticipated, the industry has been beset by technical, regulatory and commercial challenges. Here, Gi introduces the latest challenge – a particularly pernicious class of contaminant: siloxanes.

In the UK, the injection of biomethane into the gas grid is at a developmental stage. But while only two biomethane network entry facilities (BNEFs) have yet been launched (that of Scotia Gas Networks (SGN) in Didcot, Oxfordshire, and the Poundbury plant in Dorset), it is clear the industry has great potential.

As the most energetically efficient use for biogas, it is hoped that up to 10 per cent of the UK's natural gas demand could be met by biomethane grid injection, adding billions to the UK economy annually.

Crucially, biomethane also provides opportunities to enhance the security of the UK's energy supply, reduce harmful carbon and methane emissions, and to support domestic and EU renewable energy targets.

With the right quality and composition of biomethane all of this can be achieved through the existing grid and conventional natural gas appliances too. Natural gas-powered vehicles can also run on biomethane of an appropriate specification.

Realising the potential benefits, the government has introduced the Renewable Heat Incentive (RHI), a financial mechanism whereby biomethane producers are given additional subsidies on top of their individually negotiated contracts to supply the "green gas".

While producing biomethane could therefore become a lucrative business opportunity, at present there are still significant technical, regulatory and commercial issues to overcome.

For example, producers are compelled under the Gas Safety Management Regulations GS(M)R 1996 and through individual network entry agreements (NEAs) to ensure they supply biomethane at consistent rates and volumes, and the gas must be of a safe and legally compliant quality and composition.

It is therefore cleaned of contaminants, upgraded to impart certain burn characteristics and odourised with a suitable stenching agent prior to grid injection.

The GS(M)R were drafted long before design and construction of the UK's first

Figure 1: Launched and in build UK Biomethane Network Entry Facilities (BNEFs)

LAUNCHED:			
BNEF:	**Launched:**	**Gas distribution network:**	**Biogas source:**
Didcot Water Treatment Plant, Oxfordshire	2010	Scotia Gas Networks (SGN)	Waste water
Anaerobic digester/BNEF, Poundbury, Dorset	2012	SGN	Agricultural
IN BUILD:			
BNEF:	**Due for completion:**	**Gas distribution network:**	**Biogas source:**
Upgrade plant/BNEF, Vale Green, near Evesham	2013	Wales & West Utilities (WWU)	Agricultural
Upgrade plant/BNEF, Doncaster	2013	National Grid (NG)	Agricultural
Upgrade plant/BNEF, Stockport	2013	NG	Food waste
Biogas compressor, Crouchland Farm, Sussex, road transport to BNEF	2013	SGN	Agricultural
Anaerobic digester/BNEF, Minworth, Warwickshire	2014	NG	Agricultural

Figure 2: Typical constituents of raw biogas prior to cleaning, enrichment and odourisation

Constituent	Typical quantities
Methane	50-85%
Carbon dioxide	5-50%
Nitrogen	0-5%
Hydrogen sulphide	0-3%
Oxygen	0-2%
Hydrogen	0-1%
Metals	0%-Trace
Volatile compounds	0%-Trace
Semi-volatile compounds	0%-Trace
Metals	0%-Trace
Siloxanes	0%-Trace

BNEF at Didcot, so they were not designed with biomethane in mind.

It has therefore been necessary to review and develop regulation alongside technical and commercial progress to begin realising the benefits of biomethane. The most recent example is the Health and Safety Executive's (HSE) decision to grant a class exemption allowing up to 1 per cent (molar) of oxygen in the grid-bound gas.

For now though, attention has shifted from biomethane contaminants, which can threaten pipeline integrity (such as oxygen, carbon dioxide, hydrogen sulphide and water vapour), to the impact on end customers' appliances.

This latest challenge for industry and regulators revolves around a class of chemicals called siloxanes, which although found only in trace quantities in some biogas sources, are potentially destructive to domestic and industrial gas appliances.

Siloxanes

Siloxanes are a group of chemicals characterised by a distinctive silicon-oxygen linkage which are associated with manufactured products including shampoos, conditioners, shower gels, deodorants and soaps (for the advantageous physical and chemical properties which they confer).

They can therefore be found in some biogas substrates, particularly waste landfill gas and waste water, for obvious reasons. Siloxanes are not typically found in agricultural biogas feedstocks such as crops, slurries or manures.

Although over 1-million tonnes of siloxanes are produced annually by industry worldwide, biogases do not contain more than trace quantities. Siloxanes do not cause or exacerbate corrosion in steel pipelines, but even at low levels their combustion products can damage gas appliances and engines.

In the combustion gases, silica or silicates can form and a glassy coating can accumulate at the combustion site. This can cause fouling which reduces efficiency and operational life.

Fortunately, siloxanes can be detected and cleaned from biomethane, but these processes can be technically challenging and costly.

Siloxane concentration cannot always be measured on site, and even in laboratories it can be difficult to measure levels associated with appliance damage, e.g., 5 parts per million (ppm).

Dutch research findings by DNV KEMA included engine failures after only 50 hours even at such a low concentration. Levels lower than 1 ppm may be impossible to detect.

What happens next?

The GS(M)R do not contain any specific references to siloxanes so it is crucial that an acceptable, i.e. safe, upper limit is determined and implemented in the UK before significant expansion of the industry begins.

Much more research is needed however, particularly into the specific UK context. Therefore the Health and Safety Executive is expected to announce an interim upper limit this summer, so as not to stall development of the sector.

In the UK, the Energy Networks Association (ENA) has convened a Biomethane Roundtable Group, which includes IGEM, and has been examining technical, regulatory and commercial challenges associated with biomethane for grid injection, including siloxanes.

The group aims to specify and commission the necessary research to determine an upper limit which can inform permanent, safe and acceptable maximum concentrations for the longer term.

Meanwhile IGEM is preparing the UK's first standard governing grid-bound biomethane quality, which was recently issued for industry comment (IGEM/TD/16 Biomethane Grid Injection).

The European Committee for Standardisation (CEN) is also working towards producing a standard to harmonise biomethane quality across the European networks. First editions and subsequent revisions of both standards will incorporate research developments as the industry successfully expands and matures.

While at present all eyes are on the HSE amidst uncertainty around siloxanes, this issue will not be a showstopper. There will be many more technical, regulatory and commercial hurdles in the widespread roll-out and uptake of biomethane for grid injection.

But the potential producers, transporters, GDNs, government and a growing number of possible end customers remain justifiably excited about the future of this sustainable energy sector. ■

For more information about siloxanes, biomethane and biomethane network entry facilities (BNEFs) including IGEM's standards under development *IGEM/TD/16 Biomethane Grid Injection* and *IGEM/TD/17: Steel and PE Pipelines for Biogas Distribution*, please visit the website *www.igem.org.uk*, email *technical@igem.org.uk* or call a member of IGEM's Technical Services team on 0844 375 4436.

Figure 3: Cyclic and linear siloxanes (the word 'siloxane' is derived from the words 'silicon', 'oxygen' and 'alkane')

CYCLIC SILOXANES		LINEAR SILOXANES	
Example	Notation	Example	Notation
D3	Hexamethylcyclotrisiloxane	MM	Hexamethyldisiloxane
D4	Octamethylcyclotetrasiloxane	MDM	Octamethyltrisiloxane
D5	Decamethylcyclopentasiloxane	MD2M	Decamethyltetrasiloxane
D6	Dodecamethylcyclohexasiloxane	MDnM	Polydimethylsiloxane