Southern Water CHP

generating electricity from biogas at key Southern Water sites

by David Hatherill BEng PhD CEng FIMechE

There are many facets to a modern wastewater works, of which the effective treatment of waste is only one. A site's environmental footprint, including a focus on emissions and compliance with European regulations together with the efficient use of energy must also rank highly during the specification and procurement of any new plant and equipment. This paper details the model adopted by Southern Water for the generation of 'green' electricity from biogas; a model which incorporates a 15-year operations' and maintenance framework centered around the implementation and asset management of modular, combined heat and power (CHP) stations together with the latest gas treatment technologies.

Power generation plant at Budds Farm with exhaust flue in the background - Courtesy of Finning Power Systems

Background

During sewage treatment, of course, methane is produced; a potent greenhouse gas which can be harmful if vented in to the atmosphere. This is by no means a new concept and every operator will be familiar with the arguments in favour of reclaiming this biogas in order to generate electricity to power site processes.

The fuel is effectively free, and as a non-fossil source, and therefore renewable, it provides a revenue stream from a waste by-product, enabling operators to generate their own cost-efficient electrical power for site processes as well as selling electricity back to the grid in the form of renewable obligation certificates (ROCs).

Yet, there is much to be considered in the selection of a power generation system capable of operating on such a fuel source; a process which has been carefully considered and developed by Southern Water for the past decade at a number of its sites.

A decade of experience

Finning first began working with Southern Water on an initial CHP framework agreement covering five sites. With engine sizes ranging from 370kW to 750kW, these smaller installations proved an ideal test bed for a second and much larger agreement that was to follow, commencing with the Budds Farm WwTW in Havant.

CHP stations take the biogas produced during the digestion process and use it as a fuel to drive a suitable gas engine/generator package with the by-product heat captured and transferred for process heating around the works.

As such, CHP installations achieve far higher fuel efficiency than is possible at main line power stations, delivering around 40 units of electricity and 45 units of heat per 100 units of fuel. In contrast, a conventional power station and boiler combination can require up to 39 more units of fuel to produce the same power and heat output.

As part of their plant mix, CHP operators can thus expect larger savings by substituting grid electricity with their own supply, shorter payback periods to other categories of green technologies and reduced reliance on heat-generating sources, such as gas boilers.

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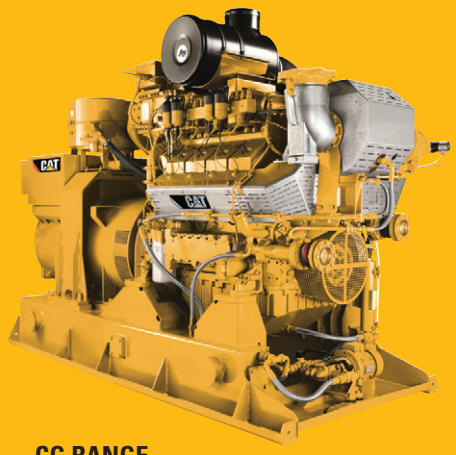

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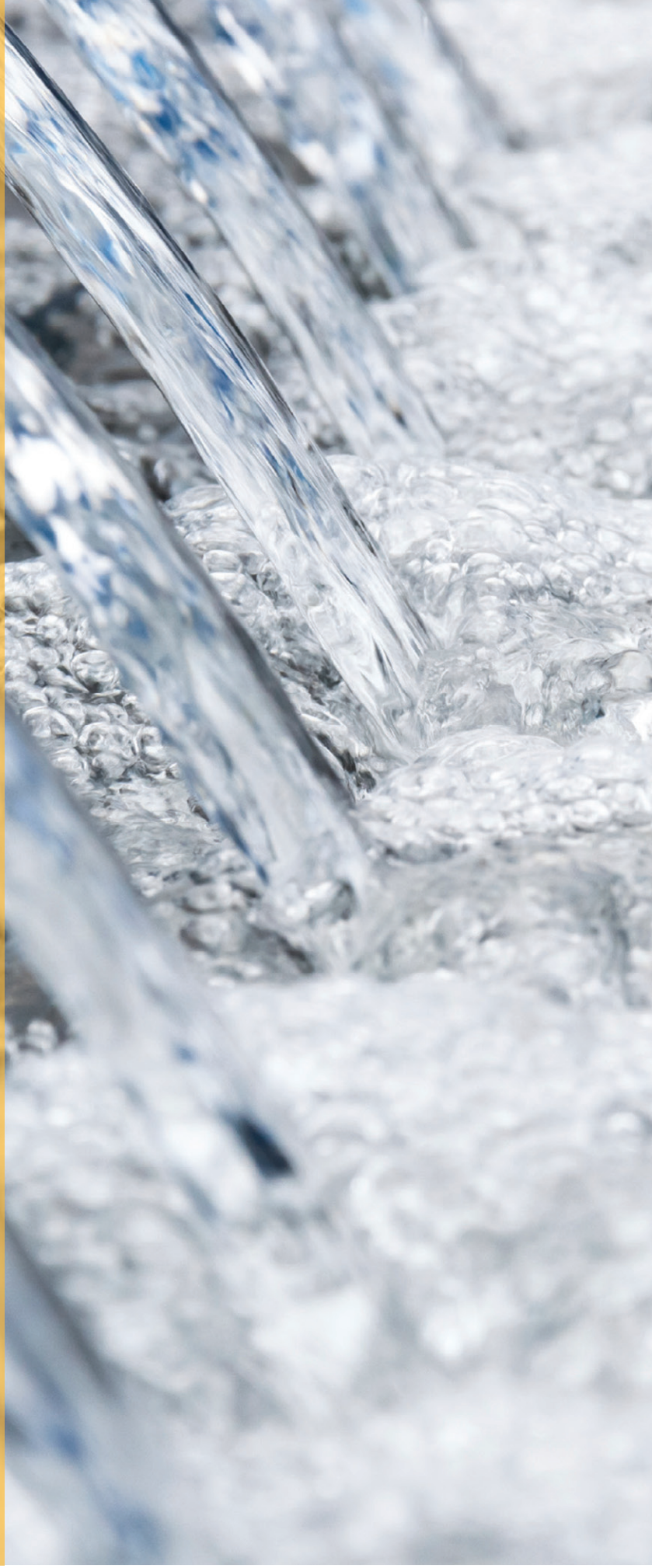

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FINNING CAT

Biogas is used to power a Caterpillar G3520C gas generator CHP package at Budds Farm - Courtesy of Finning Power Systems


Budds Farm was originally using biogas from the digester as fuel to run a sludge dryer only - Courtesy of Finning Power Systems

Budds Farm was originally using biogas from the digester as fuel to run a sludge dryer only. Finning calculated that by using the biogas to power a Caterpillar G3520C gas generator CHP package, the site would generate 1.95MWe of electrical power, sufficient to power the plant alongside heat that was available from other site processes.

Together with a commercially guaranteed 15-year operation and maintenance contract to optimise the generator's output, ensure maximum heat recovery from the available fuel and guarantee 93% engine availability, this approach has continued to be replicated at other sites across the Southern Water estate.

These include Millbrook WwTW at Western Docks in Southampton, where in 2007, a 1.15MWe modular CHP station, including all civil engineering works was developed. This was followed by Ashford WwTW in Kent, where a larger 1.95MWe CHP unit with full heat recovery was installed. Most recently, a comprehensive CHP package has been commissioned at Southern Water's showcase Peacehaven site, located 11km east of Brighton and serving a PE of 300,000 form Brighton & Hove and the surrounding area.

A modular approach

Installing a CHP system on a working site can involve considerable disruption, so Finning employs a modular approach, where much of the engineering and design is completed off site before delivery and installation. At Budds Farm, for example, package elements were divided in to four modules.

- ***Module 1***: A packaged generator set housed in an acoustic container that includes the Caterpillar G3520C gas generator and the company's LIMA control system. This covers all of the synchronisation, G59 and remote monitoring requirements and connects to the site's high voltage switchgear via a 2500kVa step up transformer.
- ***Module 2***: The heat recovery system, configured initially to capture 716kWt of heat from the engine jacket water circuit due to additional heat being available from other site processes. This was added to earlier in 2013 with the retrofitting of an exhaust gas heat exchanger due to changes in site set up.
- ***Module 3***: A gas collection and compression station that also removes some of the solids and vapour from the biogas.
- ***Module 4***: A gas clean up skid that removes other contaminants such as siloxanes and hydrogen sulphide. This fourth module uses new regenerative filtration instead of activated carbon filters to remove the siloxanes, lasting up to five years and eliminating the problem of waste carbon disposal.

In addition, at Peacehaven, the CHP package has a duel gas train allowing it to run on either biogas or natural gas. This was an important consideration for Southern Water as without power, vital processes in the plant cannot operate. The package is therefore configured to run in island mode should the site suffer a mains power failure, enabling processes such as the supply of heat to the digesters, to remain at full capacity.

A final gas management package was supplied, including gas boosters to raise the fuel gas pressure from 15mBar to the 150mBar required by the generator sets, gas meters to meet CHPQA requirements for 'good quality' CHP and online gas analysis to measure the methane, oxygen and hydrogen sulphide content of the fuel gas.

This modular approach has several benefits. First, all of the modules are subject to a strict factory-based quality control regime, enabling Finning to use more of its in-house engineering resource to ensure that each bespoke solution meets Southern Water's needs. Most

importantly, it halves the installation time, by minimising site works and the associated disruption.

Siloxane treatment

Biogas contains a number of contaminants. The concentration of these varies between Southern Water's sites, but all have an impact on the gas generator sets specified, the installation design, the maintenance regime and the economic viability of each project.

As well as chlorine, fluorine and hydrogen sulphide, a specific concern for Southern Water was the presence of high levels of organic silicon, known as siloxane when in its gaseous form. The major source is from toiletries and other products, which use silicon as a carrier and enter the wastewater. While they are inert at room temperature, once they enter the engine combustion zone, they typically form silicon dioxide and similar compounds, often to a depth of several millimetres.

The materials agglomerate in the combustion chamber, causing abrasive wear and hard deposits to form. These can alter the compression ratio of the engine causing detonation and valve guttering, affecting cylinder head life and reducing piston and liner life. Further to this, the agent will contaminate the lubricating oil, shortening its useful life and requiring more frequent oil changes.

High-efficiency engines, which operate with a higher exhaust oxygen content, compound the problem. Operating with a higher break mean effective pressure (BMEP) will make the engine run at higher performance, but makes it less tolerant of combustion chamber deposits. Cooler running temperatures and a leaner fuel mixture will also increase deposits, putting more pressure on both the spark plugs and the oil to reduce engine-operating life.

Until recently, options were limited. Waste high in siloxanes could be diverted away from the site, especially if it is mostly from one source, although this would require significant project investment to upgrade the treatment facility.

A fine water vapour could be injected in to the engine to help prevent deposits building up, but this is only a viable option if the fuel gas is low in acids. Another frequent option is to install activated carbon as the filtration medium. While effective at removing low levels of inorganic pollutants, these in-line filters do come with high operating costs and the need to frequently change and dispose of the saturated carbon, as on-site regeneration is not an option.

Carbon quality also has to be monitored carefully and regularly as the time taken to reach saturation can alter as the siloxane concentration changes.

Finning was able to engineer an alternative, coalescing gas filtration solution, which uses a regenerative filter with a media life of around five years. This allows efficient removal of 95% of the siloxane, water droplets and particles above one micron from the fuel on a continuous, unattended basis. It also has the advantage that there is a very minimal cost to regenerate the media and no real cost penalty if the media is regenerated before it is exhausted. It also removes the expense and issue of waste carbon disposal.

The siloxane filter is fitted with a GSM modem for remote monitoring to ensure that it is performing efficiently at all times. As a result, Southern Water's engine availability is increased with longer service and overhaul intervals, significantly reducing operational running costs. A vent burner is also installed to burn the contaminants that are flushed from the filter, stopping the issue of odours.

O&M contract

As part of the framework Finning provides an all-inclusive O&M contract operating at each site for a period of 15 years from commissioning. This not only factors in the ongoing maintenance of the CHP engines, gas filtration system and other ancillary equipment, but also provides comprehensive asset management of all the plant supplied by Finning. This ensures continued compliance in the face of changing regulations and requires the provision of quality service through the term of the agreement; ranging from emergency repairs and preventative maintenance to remote monitoring and the supply of genuine spare parts.

Finning, a leading supplier of biogas and low-energy fuel generators, has extensive experience in CHP for durability, economy and reliability and to help customers reach environmental targets.

The company, with a portfolio of power generation projects in the UK that now exceeds £1 billion, has developed partnerships with key suppliers and other expert providers, offering services ranging from conceptual design, planning and site surveys, through to procurement, mechanical, electrical and civil design, build, installation, commissioning, finance and ongoing support.

Cat-based packages are simple to specify, easy to install and operate, with a wide range of factory-designed and supported options. These include single and three-phase, low and high voltages, paralleling capabilities, sound-attenuated enclosures and containers, fuel systems, telemetry and remote control for automatic unmanned operations.

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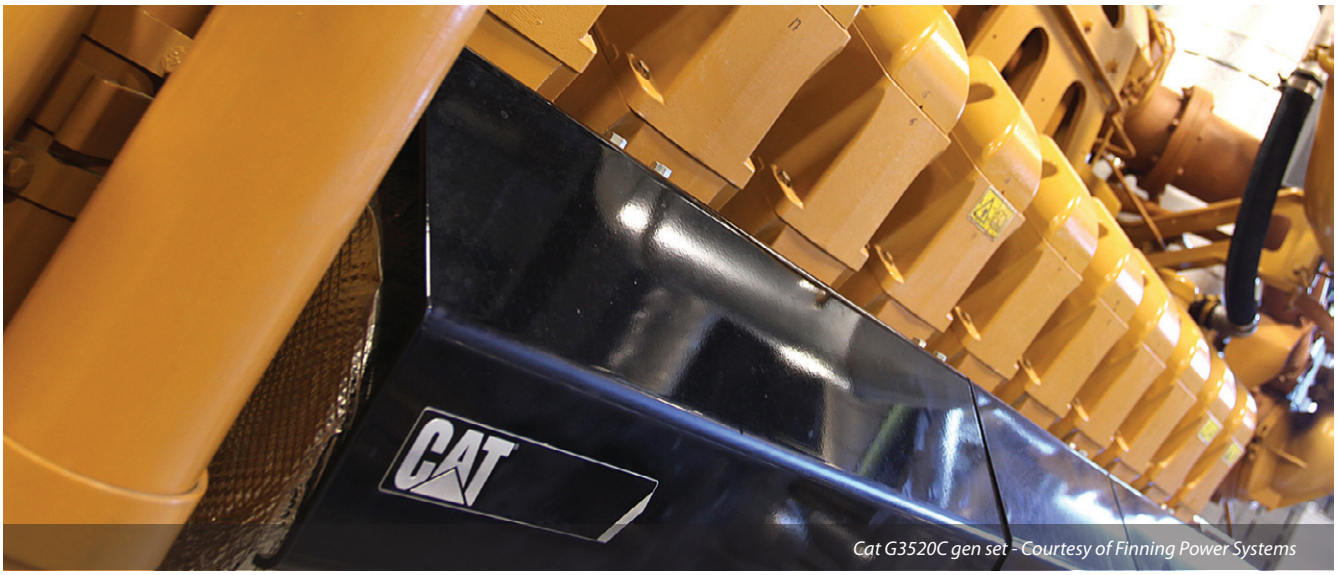

Cat G3520C gen set - Courtesy of Finning Power Systems