Biomethane Study: Stage 2
Sewage Biogas Conversion from Electricity Generation to Biomethane Injection Report

25th January 2022

Mohammad Hassaan
CNG Services Ltd

mohammad.hassaan@cngservices.co.uk
www.cngservices.co.uk

cng services ltd

CNG Services Ltd

- CNG Services Limited (CSL) provides consultancy, design and build services to the biomethane industry, all focused on reducing Greenhouse Gas (GHG) emissions
- In the past 10 years our efforts have produced a material impact with an estimated 20 year project life reduction in CO_2 emissions of 17,500,000 tonnes through:
  - Biomethane injection into the gas grid
  - Running trucks on Bio-CNG
  - Acting as developer and design and build contractor for the Highlands CNG Project
- Part owner of CNG Fuels Ltd, a company set up to build a national network of Bio-CNG stations on the high pressure grid
  - National network of CNG Stations
  - 84% saving in GHG compared to diesel
- Part owner of Barrow Shipping Ltd, GB's leading shipper of biomethane and a company that only buys and sells biomethane, no fossil gas
- CSL is an ISO 9001, 14001 and 45001 approved company and has also achieved Achilles certification. CSL is GIRS accredited for design and project management and has been certified as a competent design organisation for high pressure UK onshore natural gas works by DNVGL
- Working on a number of H_2 and CCUS innovation projects

About this report

Report Aim

This report covers stage 2 of three separate stages as part of this overall research project detailed below:

- Stage 1 Adapting and reviewing the CSL central injection hub model and associated economics to be applicable for the GB regime. Includes comparison with Reverse Compression to create capacity
- **Stage 2 Adapting and reviewing CSL work on sewage biogas conversion of utilisation from electricity generation to biomethane injection**
- Stage 3 Report on the mandatory requirements:
    - Including biogas to electricity plants
    - Identifying areas with highest potential for new AD
    - Identifying commercial barriers and opportunities

Participating Parties

Lead Partner	*Participating Partner*	*Project Coordinator*	*Supported By*
NGN	WWU	EIC	ENA

Northern Gas Networks · WALES&WEST UTILITIES · EIC Together we innovate · ena energynetworks association

Report Structure

cng services ltd

Document Control

Document Control	
Document Title	Sewage Biogas Conversion from Electricity Generation to Biomethane Injection Report
Document Reference	834-01-BMDO-001-C
Revision Date	25/01/2022
Notes	Final Report
Document Author	Mohammad Hassaan
Project Manager	Colin Brewster
Project Director	John Baldwin

Issue Record

Name	*Company*	*Date Issued*
Emma Buckton	NGN	25/01/2022
Ashley Burnhope	NGN	25/01/2022
Peter Thomson	NGN	25/01/2022
Helen Fitzgerald	WWU	25/01/2022
David Harding	WWU	25/01/2022
Geraint Herbert	WWU	25/01/2022
Claudia Sequeira	EIC	25/01/2022
Katie Harrison	ENA	25/01/2022

Document Version

	Prepared by	**Reviewed by**	**Approved by**
Final Report Version C	Mohammad Hassaan	Colin Brewster	John Baldwin
Date	**Signatures**		
25/01/2022	MH	CB	JB
Draft Revision Version B	Mohammad Hassaan	Colin Brewster	John Baldwin
Date	**Signatures**		
10/01/2022	MH	CB	JB
Draft Report Version A	Mohammad Hassaan	Colin Brewster	John Baldwin
Date	**Signatures**		
08/12/2021	MH	CB	JB

Acronyms

AD	Anaerobic Digestor
AGI	Above Ground Installation
BUU	Biogas Upgrading Unit
CBM	Compressed Biomethane
CNG	Compressed Natural Gas
COMAH	Control of Major Accident Hazards
CSL	CNG Services Ltd
CUB	Compressed Upgraded Biogas
DX	Distribution Network
GDN	Gas Distribution Network
GEU	Grid Entry Unit
GGSS	Green Gas Support Scheme
IP	Intermediate Pressure Gas Network
LP	Low Pressure Network
LTS	Local Transmission System
MP	Medium Pressure Network
NGN	Northern Gas Networks
NTS	National Transmission System
O&M	Operation and Maintenance
PRMS	Pressure Regulating and Metering Skid
RHI	Renewable Heat Incentive
REGO	Renewable Energy Guarantees of Origin
RO	Renewables Obligation
ROCs	Renewables Obligation Certificates
TDS	Tonnes Dry Solids (of sewage sludge)
TX	Transmission Network
WACC	Weighted Average Cost of Capital
WWU	Wales & West Utilities

Glossary

Biogas	The product gas from the anaerobic digestion process, typically produced from organic waste materials or energy crops (i.e. maize). A typical biogas composition is 60% methane (CH4) and 40% carbon dioxide (CO2).
Biomethane	Biogas that has been cleaned and purified to remove any contaminants and the majority of the CO_2. This results in a composition of <97% methane with a balance of nitrogen, oxygen and CO_2. If biomethane is produced for grid injection purposes, it must meet the specification set by the local grid which may require the addition of propane and odorant.
Bio-CNG	Biomethane that has been injected into the gas grid un-tariffed and transported through the network by means of mass balancing. The biomethane can then be taken out of the grid at a remote point and compressed to 250 barg for use as a vehicle fuel.
Compressed Biomethane (CBM)	Biomethane that has been compressed to >250 barg for use as a vehicle fuel or transportation (when it can be injected directly into the grid without further enrichment). Portsdown Hill and Adapt Biogas at Somerset Farm .
Compressed Upgraded Biogas (CUB)	Biogas that has been upgraded and compressed to >250 barg for transportation however requires enrichment (i.e. the addition of propane and odorant) to meet the grid specification prior to being injected into the gas grid. This is specific to gas being produced/transported to the Vale Green site via Central Hub and also VR Doncaster and the Acorn Bioenergy Sites.
Central Hub	The transmission of gas that occurs without the use of a conventional pipeline. The most common method being via gas trailers. Also referred to as a virtual pipeline.
Mother Station	A CBM filling station that exports gas via trailers to a daughter station. The mother station for this study is located by the biomethane producer to export gas.
Daughter Station	A CBM decanting station that allows the unloading of gas from trailers to be used at the facility. The daughter station for this study is located at the grid connection where the gas will be injected.
Tonnes Dry Solids (TDS)	Sewage sludge is typically measured in tonnes of dry solids (TDS) which is produced after dewatering, drying and heating processes. This notation is also used for the transportation of sewage sludge as %TDS (percentage of dry solids) which provides the thickness/viscosity of the sludge and water content.

Project Brief

Scope

CNG Services Ltd have been commissioned to review the economic and technical challenges for water companies in changing the use of sewage derived biogas from generating electricity to generating Biomethane to be injected into the gas grid.

This report is a research study for the Energy Innovation Centre (EIC) and is funded by Northern Gas Networks (NGN) and Wales & West Utilities (WWU).

This report will identify areas for potential growth in biomethane production, by reviewing both feedstock potential and gas grid capacity, to identify suitable clusters or key target plants than could convert from CHP to biomethane injection, with minimal effort for maximum economic, environmental and social benefit.

The problem

- Support for Anaerobic Digestion (AD) with CHP projects is weakening.
- RO (Renewables Obligation) support will start expiring within the next 5 years for the early adopters and under current regulations.
- FIT (Feed-In Tariffs) supported projects are unable to replace ageing CHP engines without compromising their FIT accreditation.
- The cost of getting biomethane to market caused by GDN MP/IP grid capacity being taken in many areas due to the 110 biomethane projects completed to date.

Green Gas Support Scheme

The Green Gas Support Scheme (GGSS) will replace the Renewable Heat Incentive (RHI) for 4 years as of March 2021.

- Only supports biomethane produced by anaerobic digestion of biomass feedstocks and injected into the gas grid.
- Tier based tariff support scheme for a 15 year period from plants registration

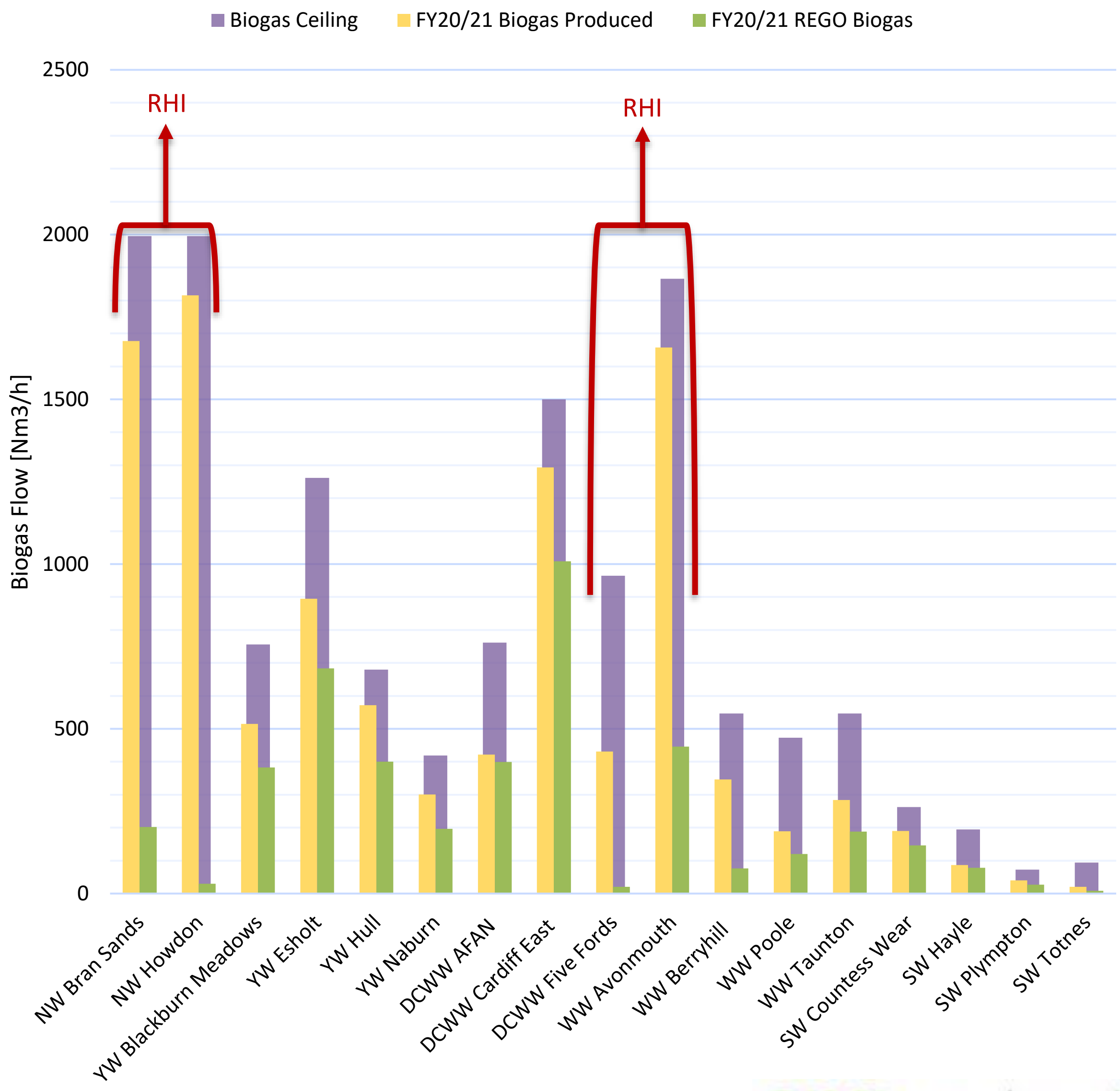
Executive Summary

Current Water Company Facility & Potential

- Northumbrian Water have previously made the switch and having found success now operating both primary AD sites with the RHI scheme.
- For Yorkshire Water without considering refurbishment, the Esholt facility is the optimal site for conversion as it has the largest sewage capacity as well as facility that accepts sewage on road by tankers.
- Welsh Water operate Five Fords under the RHI scheme and operate it efficiently. The Cardiff and Afan plants are very suitable given the sites total capacities and current operating capacities as shown to the right.
- Wessex Water are currently reviewing their bioresource strategy. Wessex Water's Avonmouth site operates under the RHI scheme. It is likely the Taunton site will increase in capacity since it is an advanced AD like Avonmouth. As the other facilities are conventional AD or liming, diverting sewage to it will result in significant benefit in the facilities primary operation.
- South West Water are likely in the best position for the conversion since within the next two years the south west sites will lose their ROCs income. They are in a good position to consider the GGSS as it will assist in transitioning to advanced AD as they do not currently have such facility.

Advantages Biogas CHP Conversion to Biomethane Injection

- The base financial value of the GGSS is more than the value from the RO scheme.
- Upgrading biogas to biomethane captures a significant amount of CO_2 which can be permanently removed from the atmosphere.
- Biomethane run CHP has better performance and requires less maintenance compared to biogas run CHP. Generator companies can easily facilitate the change in fuel (as sewage biogas already consists of approx. 60% CH_4).
- Competent operation can lead to zero amount of fuel being flared. Biogas and biomethane are a much worse greenhouse gas compare to raw CO_2.



Introduction

Project Introduction

CNG Services Ltd have been commissioned to review the economic and technical challenges for water companies in changing the use of sewage derived biogas from generating electricity to generating Biomethane to be injected into the gas grid. This report is a research study for the Energy Innovation Centre (EIC) and is funded by Northern Gas Networks (NGN) and Wales & West Utilities (WWU) and hence the sites studied have been limited to the water companies whose region overlaps to the NGN or WWU gas network regions.

This report identifies the areas for potential growth in biomethane production, by reviewing sewage gas feedstock potential to identify suitable clusters or key target plants than could convert from CHP to biomethane injection.

Project Outline

The key points covered in this document include:

- Understanding current water company operation with regards to biogas output.
- Technical overview of a biogas CHP conversion to biomethane injection.
- Financial differences occurred from the conversion.
- Environmental benefits of upgrading biogas to biomethane.
- Barriers, challenges and available opportunity from this process.

Waste Water Treatment

As part of the challenges posed by climate change and to bring benefit to customers, environment and society, Ofwat has been changing the way the water sector is regulated. One of which is the development of the bioresource services which covers the wastewater sludge transport, treatment, recycling and disposal.

One of the by-products from the bioresource services is biogas which commonly used for CHP in the sector or upgraded to biomethane to be exported to the gas grid. This is the primary focus of this report. The process is detailed in the following page and falls under the control point number 2 bulleted below.

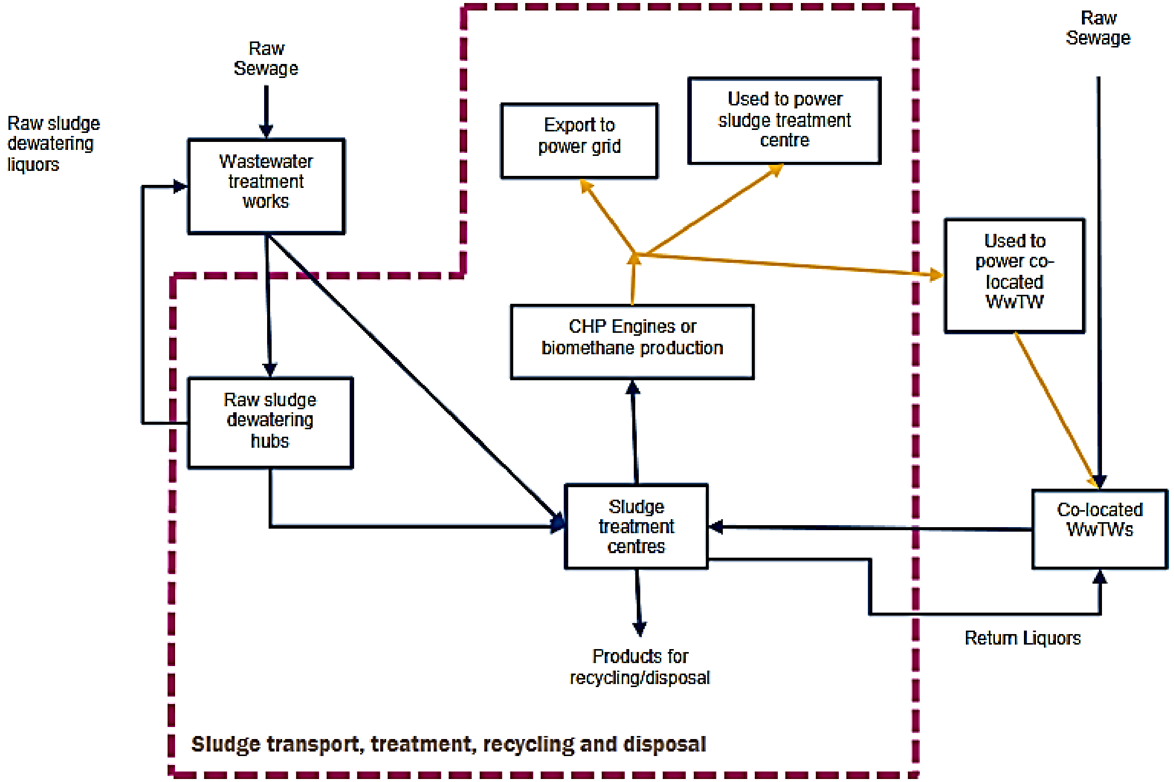
As part of the Ofwat Price Review 2019 water companies can receive revenue from customers to safely treat bioresources produced and are incentivised to look for the most efficient option. They are not under any obligation to use their own facilities or people to transport, treat, recycle or dispose of these bioresources.

Wastewater Bioresources Control

1. Sludge transport – Includes all types of transport and associated fuel costs to the treatment plant except for transport within a treatment plant.
    - Typically diesel tankers but some water companies are exploring CNG (Severn Trent) or biodiesel (Northumbrian Water).

2. Sludge treatment – Includes all activities related to sludge treatment.
    - Biogas is produced during the anaerobic digestion process along with digested sludge.

3. Sludge disposal – Includes the collection of treated sludge, transport and disposal (i.e. landfill and agriculture)



General Bioresource Boundary. Source - Delivering Water 2020: Our final methodology for the 2019 price review. Appendix 6: Bioresources control

Biogas Production From Waste Water Treatment Process

1. The sewage sludge resulting from primary and secondary water treatment is gathered for AD.

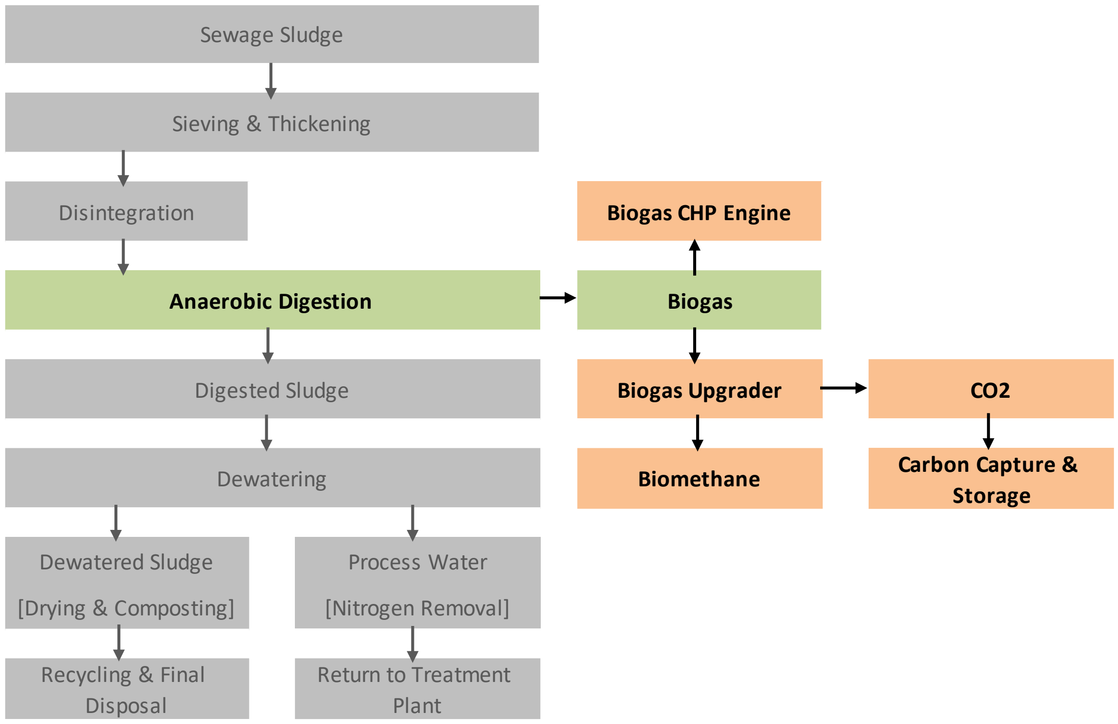
2. Before entering the digesters, the sludge is sometimes sieved and is then thickened to a dry solids content of up to 7% in order to avoid too high energy consumption for heating due to excessive water content.

3. Optionally, the sludge can be pre-treated by disintegration technologies with the aim to improve the gas yield

4. The sludge is pumped into the anaerobic continuously stirred tank reactors where digestion takes place. During a retention time of around 20 days, microorganisms break down part of the organic matter that is contained in the sludge and produce biogas, which is composed of methane, carbon dioxide and trace gases.

5. The raw biogas needs to be dried and hydrogen sulphide and other trace substances removed in order to obtain a good combustible gas and avoiding corrosion or unwanted deposition in the combustion equipment.

6. For biogas produced from sewage sludge (as well as from landfills), particular attention must be paid to the concentration of siloxanes, which can lead to deposits in combustion equipment and deterioration of performance. After cleaning, the biogas can be upgraded to biomethane or it can be combusted in a combined heat and power (CHP) plant to generate electricity and heat simultaneously



Sewage Biogas Clean-Up, Upgrading and Delivery

Biogas

Biogas arising from anaerobic digestion can vary in composition on a day-to-day basis. Typically, biogas from sewage sludge contains 60-65 mol% methane and 35-40% carbon dioxide. Smaller amounts of nitrogen and oxygen, together with trace amounts of contaminants such as hydrogen sulphide and Siloxanes may also be expected

Removing carbon dioxide from biogas increases its calorific value and, when most of the carbon dioxide has been removed, the gas remaining (usually in excess of 95-97 mol% methane) is termed "biomethane".

Biomethane is generally acceptable for injection into natural gas distribution systems but requires enrichment of calorific value using commercial propane. Under the current regulatory and commercial regime for the UK gas industry propane enrichment of biomethane is necessary to avoid consumers close to the injection point receiving gas with a CV that is too low compared to the CV on their gas bill.

Example biogas data reviewed from previous sewage gas projects include:

• CH4	60.94%	Max 66%	Min 54%
• CO2	36.78%	Max 39%	Min 31%
• O2	0.64%	Max 1.3%	Min <0.1%
• N2	1.81%	Max 5.5%	Min 0.9%
• H2S	201ppm	Max 358ppm	Min 122ppm

Biogas to Biomethane

To permit delivery of biomethane to the grid the gas must comply with the GDNs standards and GS(M)R.

In principal the biogas needs to be stripped of CO2, water, H2S and Siloxanes to maximise the CV and remove undesirable elements and then enriched with propane to raise the gross CV to the level required by the grid operator before the addition of an odorant and injection at the correct pressure.

The following main components are employed:

- Siloxane filter – activated carbon or regenerative type.
- H2S filter – media (activated carbon), chemical (HCl), biological
- CO2 removal system - Water wash, chemical wash, membrane, PSA or cryogenic
- Propane enhancement – Blending unit with control and bulk storage
- Network Entry Module – Monitors gas quality, controls outlet pressure, adds odorant and permits gas to flow to grid.
- System flare

Renewables Obligation Scheme

Renewables Obligation (RO):

The Renewables Obligation is a support scheme for renewable electricity projects in the UK. It puts an obligation on UK electricity suppliers to source an increasing proportion of their electricity from renewable sources.

The RO is underpinned by legislation and there are three "RO Orders" that cover England and Wales, Scotland and Northern Ireland.

Renewables Obligation Certificates (ROCs):

A Renewables Obligation Certificate (ROC) is issued for eligible renewable electricity generated by an accredited generating station. The number of ROCs issued for every megawatt hour of renewable electricity generated will depend on the technology used at the station, and its capacity and location.

Operators of generating stations can sell ROCs to licensed electricity suppliers, or to other intermediaries. Licensed electricity suppliers use ROCs to demonstrate their compliance with their obligations under the scheme. ROCs are issued monthly or annually, subject to submitting the required data within the specified timeframes, and all other criteria being met.

Renewable Energy Guarantees of Origin (REGO):

The Renewable Energy Guarantees of Origin scheme certifies the origin of renewable electricity. Ofgem issues Renewable Energy Guarantees of Origin (REGOs) to accredited generating stations in the United Kingdom. One REGO is issued for each megawatt hour (MWh) of eligible renewable output electricity generated (with effect from 5 December 2010). Before 5 December 2010, one REGO was issued for each kilowatt hour (kWh) of eligible renewable output generated.

Obligation Period (1 April - 31 March)	Buy-out Price	Obligation For England & Wales and Scotland (ROCs/MWh)
2010 – 2011	£36.99	0.111
2011 – 2012	£38.69	0.124
2012 – 2013	£40.71	0.158
2013 – 2014	£42.02	0.206
2014 – 2015	£43.30	0.244
2015 – 2016	£44.33	0.29
2016 – 2017	£44.77	0.348
2017 – 2018	£45.58	0.409
2018 – 2019	£47.22	0.468
2019 – 2020	£48.78	0.484
2020 – 2021	£50.05	0.471
2021 – 2022	£50.80	0.492

2021 Green Gas Support Scheme Comparison

Tier 1 – 60,000MWh	5.51 p/kWh
Tier 2 – 40,000MWh	3.53 p/kWh
Tier 3 – >100,000MWh	1.56 p/kWh

Project Methodology

Sewage Company	Gas Network	Total DNC (kWe)	Estimated TIC (kWe)
Northumbrian Water	NGN	10,971	11,797
Yorkshire Water	NGN	12,987.1	13,965
United Utilities	Cumbria - NGN	(None in Cumbria) 29,598.59	(0) 31,827
Dwr Cymru Welsh Water	WWU	12,288	13,213
South West Water	WWU	1,700	1,828
Wessex Water	WWU	4,370	4,699

Declared net capacity (DNC)

The maximum capacity at which the station or installation could be operated for a sustained period without damaging it (assuming the source of power used by it to generate electricity was available to it without interruption) minus the amount of electricity that is consumed by the station.

Total installed capacity (TIC)

The maximum capacity at which an eligible installation/station could be operated for a sustained period without damaging it (assuming the source of power or eligible low-carbon energy source was available to it without interruption. TIC is generally the total kW rating of the generating equipment.

TIC = DNC + Amount of electricity consumed by the station

Analysis Selection Criteria

Using sourced data, analysis was done to 5 sewage companies shown in the left table. Only sewage companies with transposing regions to NGN and WWU were analysed. These companies are registered with the RO scheme with Ofgem.

The primary scope of analysis is the financial year of 2021.

Biogas Analysis

Based on the site capacities, sludge flow, energy flow, CHP data and energy production, estimations were calculated for the biogas ceiling, the biogas produced for the financial year 2020-2021 and biogas combusted to generate electricity.

The biogas ceiling is the total amount of biogas that can be produced by a facility and is limited by the maximum amount of sewage sludge an AD site can facilitate.

The biogas produced during the financial year 2020-2021 is based on the actual quantity of sewage sludge that water company bioresources teams record. Naturally this is lower than the biogas ceiling with fluctuations seen each financial year. Based on data seen on existing sites, for advanced AD 400-460Nm3 of biogas can be produced per TDS and is a non static figure and in theory approx. 50% of the dry organic matter can be converted into biogas.

The biogas combusted can be calculated based on the CHP and Ofgem data. This is the amount of biogas that has been used to generate electricity including the losses due to CHP inefficiency.

For safety reasons excess biogas is flared and is estimated to be the difference between the 2020-2021 total load and 2020-2021 combustion load.

Data Input Into Study

Ofgem Public Record

The Ofgem Renewable and CHP Register provides a record of generating stations across the UK, and the capacities of each station. The register provides access (3 months in arrears) to the following generation data:

- Total Installed Capacity;
- Declared Net Capacity;
- Location address;
- Commissioning date;
- Monthly eligible generation volume by sector and by location;
- Sector and current operator.

These data can be further interrogated to provide average generation run rate by location, and the likely generator mix installed at each location. Simply deducting the declared net capacity from the total installed capacity produces the size of the ineligible load calculated by the operator, and therefore produces a factor which can be applied to the register generation volume data to calculate the gross generation at each location.

Each operator has an obligation under the Order to provide up to date data to Ofgem, allowing the regulator to maintain the register accurately.

Generator Data

CSL has been successful in securing anonymised generator data from the major UK suppliers, relating to the numbers of generators sold into the sewage gas market, the mix of capacity, the year of sale, and the major fuel supply issues experienced.

The data provided has been subdivided into operator group, number of locations and the number of generators of each model type and capacity that have been supplied.

Cross referencing the generators supplied with the accredited capacity detailed on the register will facilitate a reasonable allocation of generator type to each location. This will allow CSL to estimate the average run rate by location and possibly by generator, which in turn facilitates the estimation of the electrical efficiency being achieved.

Data Coverage

The Ofgem data represents the over 95% of the total sewage gas generation across the UK, and provides macro trends for the sector generation behaviour. The Ofgem register provides data for over 207 MW of declared net capacity.

To date CSL has successfully secured generator supply data for over 167 MW of installed capacity, which is estimated to account for 77% of the sector when adjusted for gross generation from net capacity.

Northumbrian Water

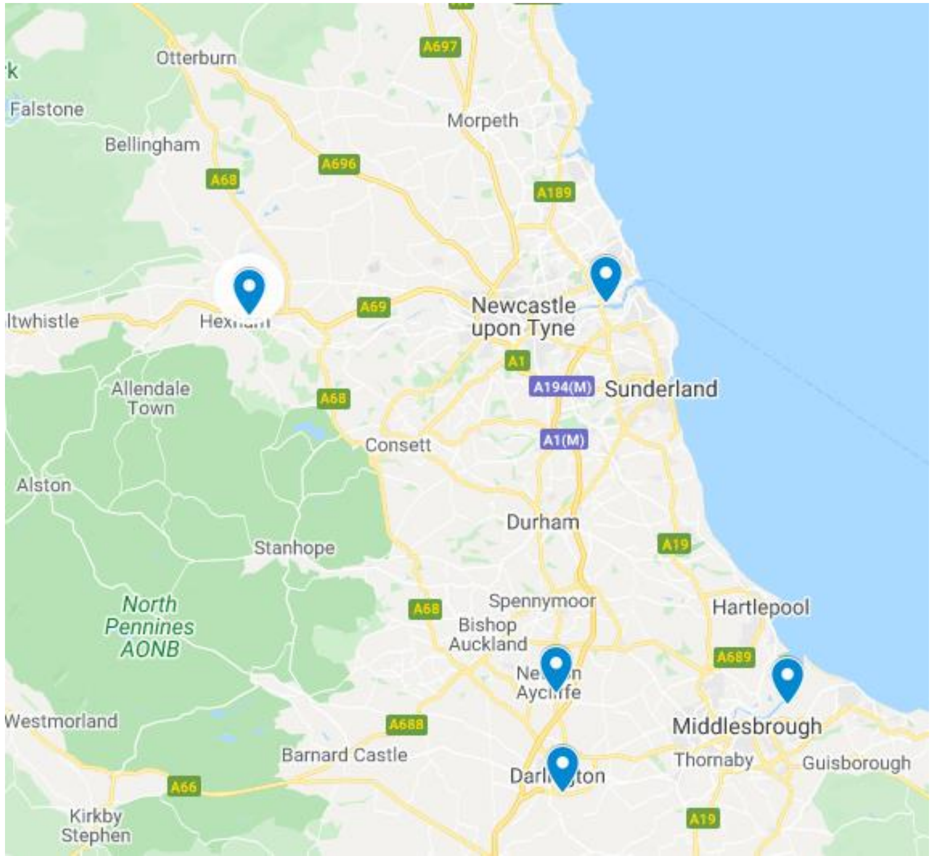
Northumbrian Water operate 5 generating stations accredited with Ofgem under the Renewable Obligation scheme as mapped to the right. However only Bran Sands and Howdon treatment centres have advanced anaerobic digestion facility. Northumbrian Water operate many other sewage treatment centres (thickening centres) that transport treated sludge (as raw cake) to Bran Sands and Howdon facilities.

CSL has supported 2 biomethane projects completed by Northumbrian Water injecting biomethane into NGN Grid at Howdon and Bran Sands. In each case Northumbrian Water has converted Biogas CHP engines to natural gas CHP.

Currently Bran Sands and Howdon operate gas engines running on natural gas which operate at average conversion efficiencies of approx. 40%. It was observed prior to the conversion projects, the engine operation can require significant amounts of maintenance depending on the quality of biogas used. During the upgrader downtimes (3%) biogas is used as the engine fuel from which Northumbrian Water claim ROCs on the electricity generated.

Northumbrian Water are also under receipt of the RHI starting from Howdon since 2014 injected biomethane into the gas grid with an energy conversion efficiency of over 95% (considerably more than the operation of its biogas engines).

The RHI contract for Northumbrian Water is due to end 2035 for Howdon and 2040 for Bran Sands.



Renewable Obligation Accreditation Number	Live Generating Stations	Station DNC (kWe)	Accreditation Date	Commission Date	Generating Station Address
R00179RREN	Bran Sands (RSTC Advanced Digestion) Facility	4591	08/11/2009	08/11/2009	Bran Sands, Middlesbrough, TS6 6UE
R00211RREN	Howdon AAD	5800	01/08/2012	01/08/2012	Howdon STW, Howdon, Wallsend, NE28 0QD

Northumbrian Water – Site Data & Performance

Electricity Generation

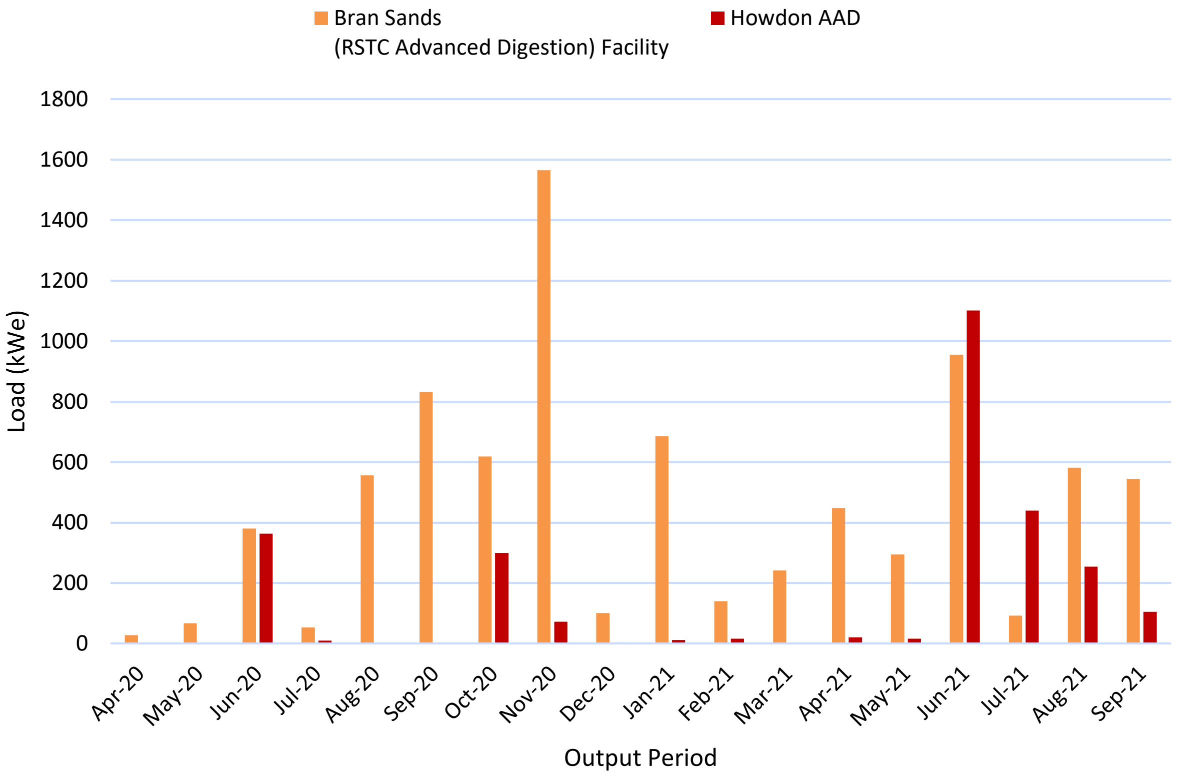
The graph to the right shows the hourly electricity loads for each month that both sites produce via biogas engines. The electricity load is generated from claimed certificates from Ofgem via the RO scheme.

Looking at the load pattern, the generation of electricity is less consistent and not proportionally larger (comparing capacity) compared to the other sewage treatment facilities explored further in the report. This is due to both sites having the ability to upgrade and inject biomethane into the gas grid and are incentivised to do so via the RHI.

Biogas Production [based upon market, public & private data]

From the table below, there is a large difference shown between the maximum possible biogas production (FY20/21 Biogas Capacity [based on TDS]) and biogas that has been used to run engines to generate electricity (REGO Biogas) with differences larger than 1400Nm3/h. As mentioned previously this is due to the sites injecting biomethane into the grid.

Note. From the below table the average load for Howdon is based on its period of operation only.



Site	Monthly Total Capacity (TDS)	Annual Total Capacity (TDS)	End Product Quantity Per Year (TDS)	Operating Hours	FY20/21 Biogas Capacity [Nm3/hr]	REGO Biogas [Nm3/hr]	Station TIC	FY 20-21 REGO Certs	FY 20-21 Average Load [kWe]	HHV (Average)
Bran Sands	3333	40,000	33,626	24/7	1677	202	4771	3843	455	1354
Howdon	3333	40,000	36,412	24/7	1816	30	6000	566	210*	644

Northumbrian Water – Learning From Enquiries

Biogas to Natural Gas Engine Conversion

Northumbrian Water have completed biogas to natural gas engine conversions with Edina (MWM) at Howdon, and Clarke (Jenbacher) at Bran Sands, both able to burn biogas or natural gas.

The design work for both cases was done at the engine manufacturers in Germany. Due to this they ran into a few issues such as the local licensee not keeping Northumbrian Water informed as much as they would have liked. Northumbrian Water found Bran Sands to be the slightly easier project, but the job for both sites was not straightforward due to long response times, scant information, and overseas design teams only engaging on their T&Cs.

It was advised if partaking in a similar project that the MWM engines will probably need to be downrated by 15%, whilst the Jenbacher ones not needing to depending on how much air can be provided to it. Also the turbocharger size will probably need to be increased.

The maximum engine life is 120,000 hours, so for potential upgrading projects, if old engines are in operation it may be better to buy new engines designed for Natural Gas and current legislation. Once the engines are ready to come to site, it takes 3-4 weeks per engine, start to start. However this is dependant on which suppliers are used and the current relationship.

Current [Natural Gas] Engine Operation

The current engines at Bran Sands and Howdon can burn either biogas and natural gas however, they can only burn one fuel at a time with a manual changeover - stop, automatic purge and then a restart on the new fuel.

The approximate current hours are 97% natural gas, and 3% biogas which occurs only when the upgrader is being maintained.

Northumbrian Water have a smaller unconverted engine at both Bran Sands and Howdon, which mops up any spare biogas, and means that the storage can be spun out longer if there are temporary issues on the upgrader. Northumbrian Water can still get ROCs from this operation, though requiring good metering and records management.

The Network Entry Agreements NGN have in place with Northumbrian Water are; Bran Sands, 1240 scmh and for Howdon, 1500 scmh. These figures are smaller than the shown FY20/21 Biogas Capacity below since Northumbrian Water were producing excess biogas which was being flared off due to limitations of the biomethane upgrade plant and the export licence agreed with NGN. Around March 2020 Northumbrian Water completed a project for the additional installation of a 2MW engine, and now the Howden site have switched over one of the engines to operate on biogas.

Site	Monthly Total Capacity (TDS)	Annual Total Capacity (TDS)	End Product Quantity Per Year (TDS)	Operating Hours	FY20/21 Biogas Capacity [Nm3/hr]	REGO Biogas [Nm3/hr]	Station TIC	FY 20-21 REGO Certs	FY 20-21 Average Load [kWe]	HHV (Average)
Bran Sands	3333	40,000	33,626	24/7	1677	202	4771	3843	455	1354
Howdon	3333	40,000	36,412	24/7	1816	30	6000	566	210*	644

Yorkshire Water

Yorkshire Water operate 20 generating stations accredited with Ofgem under the Renewable Obligation. The DNC ranges from 82 to 4166 which can be seen individually in the appendix of the report. A cut-off for the top 4 sites based on average load for the financial year 20-21 has been done for site and performance analysis. Note that some sites such as Mitchell Laithes can have a better performance than those selected but didn't do so for the 20-21 financial year. It is known the site was undergoing refurbishment and Biosolids Assurance Scheme certification but this may not necessarily be the underpinning reason why.

Yorkshire Water claimed £2.293m from ROCs for the 2020/2021 financial year and nothing for RHI as no biomethane was produced.

75,213MWh of electricity was generated from the entirety of the bioresources team, from this 489MWh was exported to the grid or third party and 7020MWh was bought additionally and used for bioresources control.

123,953MWh of heat was generated of which 114,889MWh went unused. 32,401MWh of heat was bought and used for bioresources control (suggested natural gas).

The RO schemes end for the following sites during years 2027, 2028, 2029 and 2034 sequentially.

Accreditation Number	Generating Station	Station DNC	Accreditation Date	Commission Date	Generating Station Address
R00117RREN	Naburn WWTW	595	01/04/2004	01/04/2004	Naburn WWTW YO1 4RN
R00184RREN	Hull WWTW CHPs	1404	17/12/2008	17/12/2008	Hull WWTW HU12 8EY
R00186RREN	Esholt STW CHP	4166	13/02/2009	12/02/2009	Esholt Waste Water Treatment Works BD10 0TW
R00218RREN	Blackburn Meadows STW CHP	1944	06/05/2014	29/01/2014	Blackburn Meadows S9 1HF

Yorkshire Water – Site Data & Performance

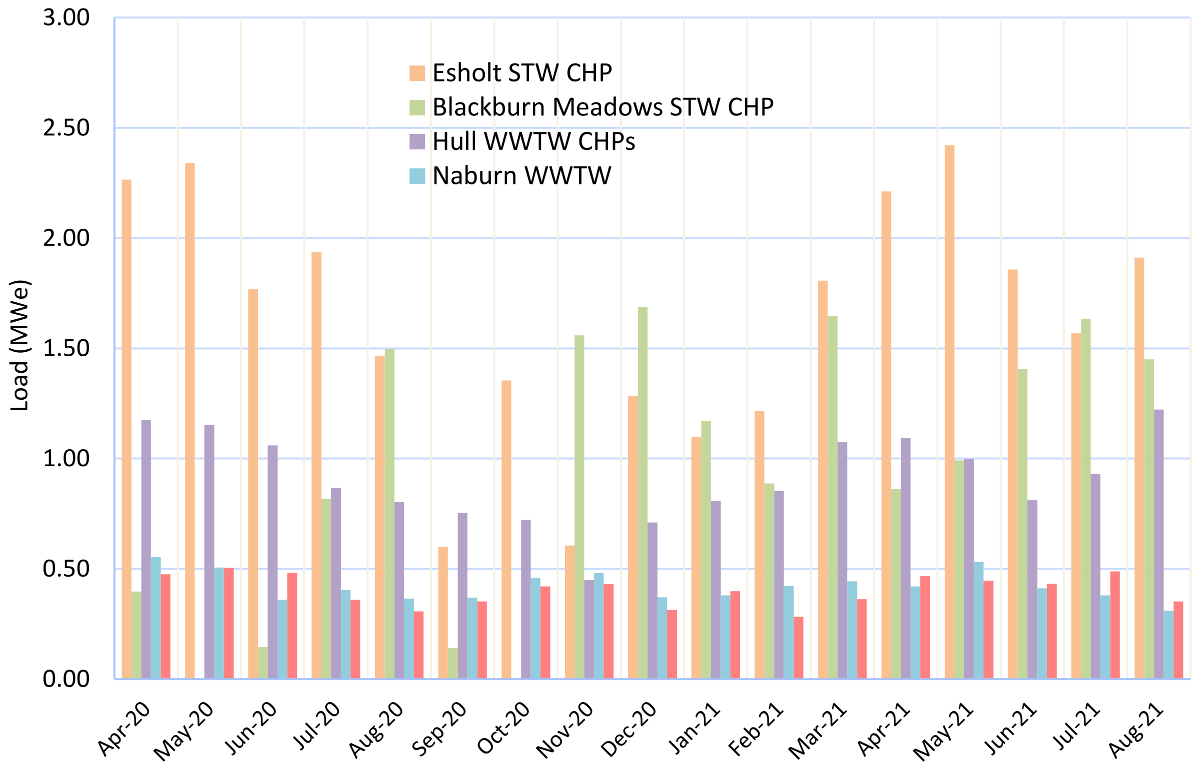
Electricity Generation

The graph to the right shows the hourly electricity loads for each month that the sites produce via biogas engines. The electricity load is generated from claimed certificates from Ofgem via the RO scheme.

Esholt is shown to be the best electricity production site form the graph to the right. It claims the most REGO certificates and its electricity load is on average 59% more than the next best performing site which is Blackburn Meadows.

Biogas Production [based upon market, public & private data]

From the table below, the sites use 65% to 74% of the total possible biogas production (FY20/21 Biogas Capacity) to run engines to generate electricity (REGO Biogas). The remaining 35% is likely to be flared due to maintenance activities or if the biogas yielded from the treated sludge was less due to inefficiencies in the AD plant or due to lower quality sludge.



Site	Monthly Total Capacity (TDS)	Annual Total Capacity (TDS)	End Product Quantity Per Year (TDS)	Operating Hours	FY20/21 Biogas Capacity [Nm3/hr]	REGO Biogas [Nm3/hr]*	Station TIC	FY 20-21 REGO Certs	FY 20-21 Average Load [MWe]	HHV (Average)
Blackburn Meadows	1263.6	15163	10,315	24/7	515	383	2000	7281	1.02	3140
Esholt STW CHP	2108*	25,299	17,940	24/7	895	683	4344	12982	1.63	5026
Hull WWTW	1135	13,624	11,470	24/7	572	400	1503	7615	0.91	2809
Naburn WWTW	700	8395	6036	24/7	301	196	612	3730	0.42	1299

Welsh Water

Welsh Water have 4 active generating stations accredited with Ofgem under the Renewable Obligation. There are a number of other generating stations but they are no longer under receipt of the RO scheme, and diverting its sewage cake to an advanced AD plant (if currently conventional AD) or have had certificates revoked.

Welsh Water are phasing out liming and conventional AD and have transitioned to Advanced AD. Advanced AD utilises thermal hydrolysis which reduces sludge volume (20%) and treatment costs, enables greater conversion of sludge to energy (1/3 more), and eliminates a large source of odour risk. It also meets an enhanced treatment standard which is more desirable to agricultural customers.

The RO schemes end during 2030 for AFAN and Cardiff East. Welsh Water's Eign plant (which is not in the WWU geographic area) will have its scheme end 2027 and towards the end of 2021, and will not accept sewage cake and will divert its sludge to an advanced AD facility (any of the other 3 listed below) as it is currently a conventional AD plant. Five Fords will have its RO scheme end 2031 and its RHI scheme end 2035 as it produced biomethane for gas to grid.

Accreditation Number	Generating Station	Station DNC	Accreditation Date	Commission Date	Generating Station Address
R00181RRWA	AFAN WWTW CHP	2962	08/10/2010	08/10/2010	Afan SA13 1RA
R00182RRWA	Five Fords WWTW CHP	1170	09/06/2012	09/06/2012	FIVE FORDS WWTW DWR CYMRU WELSH WATER LL13 0PA
R00179RRWA	Cardiff East WWTW CHP	4035	08/10/2010	08/10/2010	Cardiff East WWTWT CF24 2RX

Welsh Water – Site Data & Performance

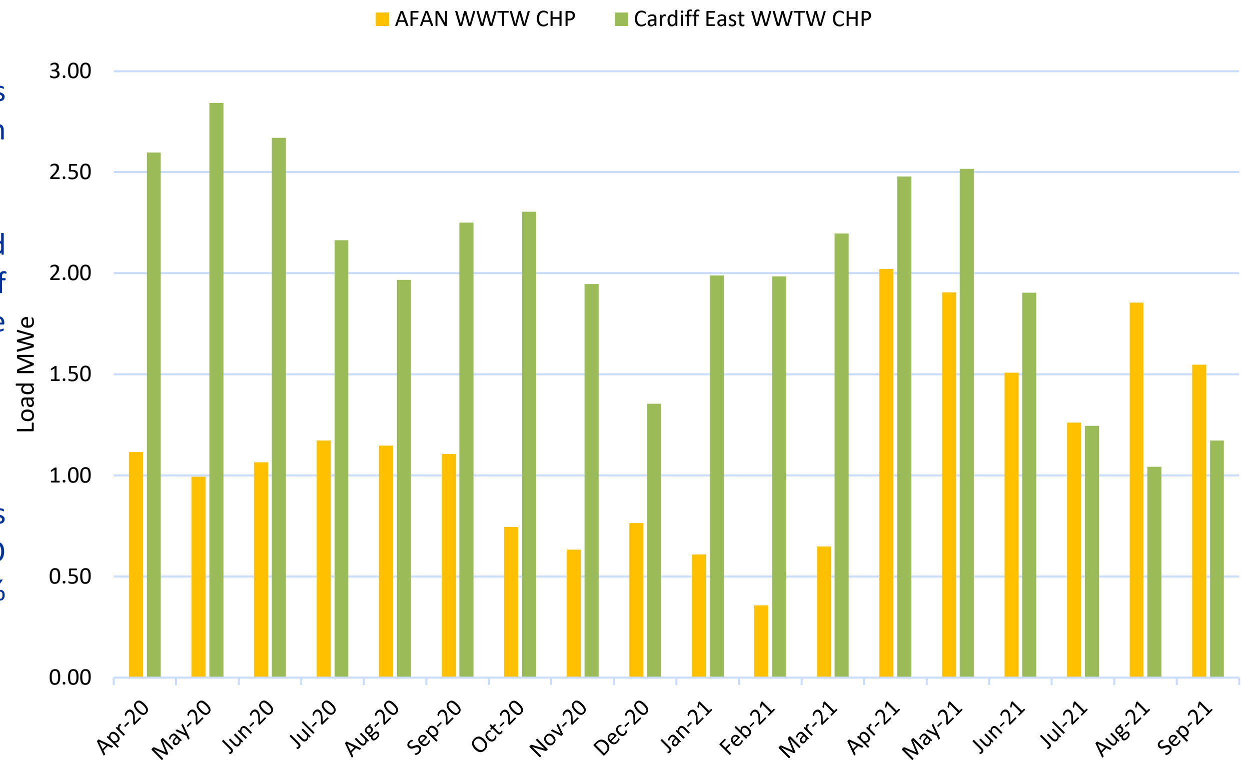
Electricity Generation

The graph to the right shows the hourly electricity loads for each month that the sites produce via biogas engines. Five Fords is not shown as it did not generate enough electricity (40kWe on average) compared to the other sites.

Cardiff East generates the most electricity based on the REGO certificates issued and has the most capacity to do so. Welsh Water divert sewage cake from a number of other sites to Cardiff East for processing. For the 2020/2021 financial year the diverted quantity was 12055 TDS as shown in the table below.

Biogas Production [based upon market, public & private data]

From the table below, the sites use 77% to 94% of the total possible biogas production (FY20/21 Biogas Capacity) to run engines to generate electricity (REGO Biogas). Proportionally Cardiff East is the least efficient in terms of biogas used at 77% as Five Fords has gas to grid capacity.



Site	Monthly Total Capacity (TDS)	Annual Total Capacity (TDS)	End Product Quantity Per Year (TDS)	Operating Hours	FY20/21 Biogas Capacity [Nm3/hr]	REGO Biogas [Nm3/hr]*	Station TIC	FY 20-21 REGO Certs	FY 20-21 Average Load [MWe]	HHV (Average)
AFAN WWTW CHP	1259	15274	8469	Mon to Fri 08:00-16:00	422	399	3072	7585	1.14	3504
Cardiff East WWTW	2480	30070	13857+12055		1293	1008	4200	19171	2.03	6275
Five Fords WWTW	1612	19345	8634		431	20	1200	380	0.04	127

cng services ltd

Wessex Water

Wessex Water have 5 active generating stations accredited with Ofgem under the Renewable Obligation. Trowbridge generating station has not been shown since its average load for 2020/2021 was 10kwe.

Wessex Water are undertaking a review of their regional sludge strategy which will affect the analysis done in this report as the electricity and biogas production may no longer follow the same trend.

To extrapolate, Wessex Water have 2 advanced AD facilities, Avonmouth and Taunton, these are likely receive an increase in sludge and therefore biogas yield. The other conventional AD facilities will likely divert their sludge should Wessex Water to follow a similar strategy that the other water companies have in operation.

The years at which the RO schemes end are to be confirmed. The Avonmouth site is accredited with the RHI scheme and can inject biomethane into the gas grid.

Accreditation Number	Generating Station	Station DNC	Accreditation Date	Commission Date	Generating Station Address
R00112RREN	Poole STW CHP Generation	1395	01/01/2004	01/01/2004	Poole STW BH17 7LG
R00107RREN	Taunton STW CHP Generation	830	31/03/2008	01/04/1990	Taunton STW TA3 5NU
R00141RREN	Berryhill STW - A,C	900	01/03/2005	01/01/1991	Berryhill STW BH8 0AJ
G00839SGEN	Avonmouth STW	5550	27/10/2003	01/01/1963	Avonmouth STW BS11 0YS

Wessex Water – Site Data & Performance

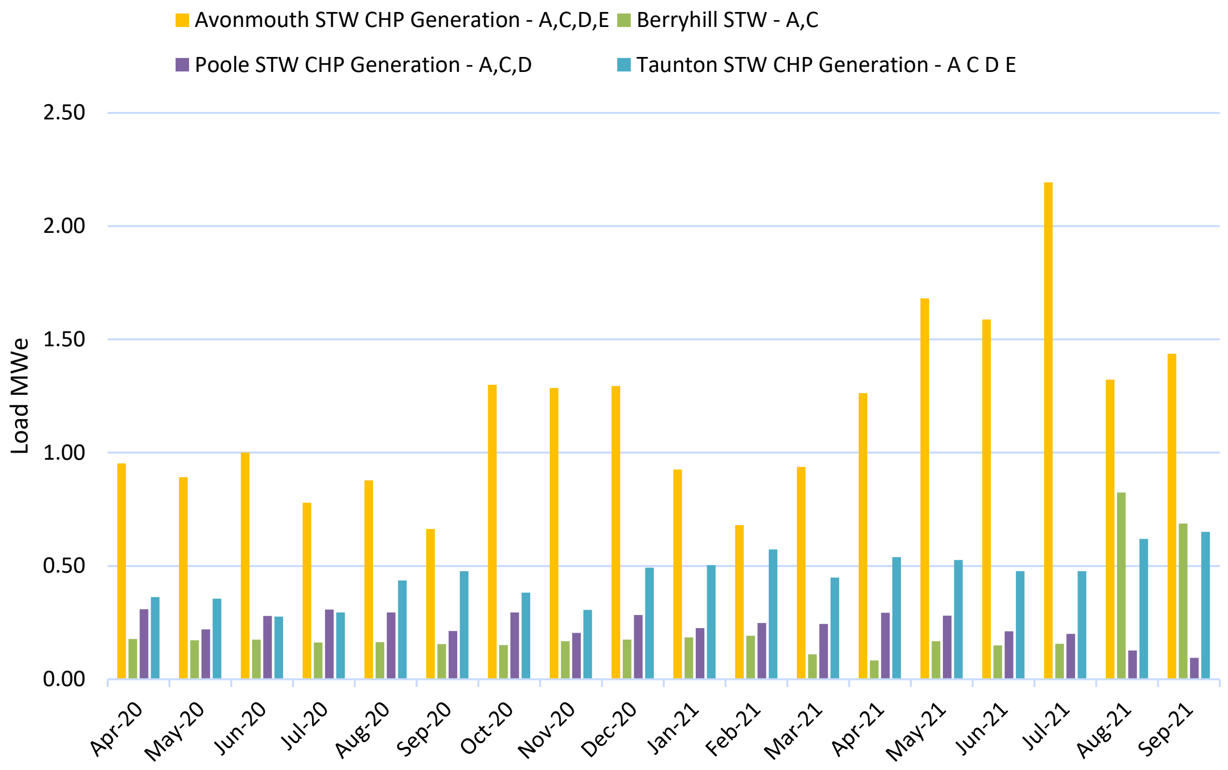
Electricity Generation

The graph to the right shows the hourly electricity loads for each month that the sites produce via biogas engines. The electricity load is generated from claimed certificates from Ofgem via the RO scheme.

Avonmouth generates the most electricity based on the REGO certificates issued and has the most capacity to do so. However based on the station capacity and average load, the site can produce significantly more.

Biogas Production [based upon market, public & private data]

From the table below, the sites use 22% to 66% of the total possible biogas production (FY20/21 Biogas Capacity) to run engines to generate electricity (REGO Biogas). Proportionally in terms of capacity Avonmouth is the least efficient in terms of biogas used at 27%. However it should be noted that Avonmouth has the facility to inject biomethane into the gas grid and is under receipt of the RHI. The site is capable of injecting 1950scmh of biomethane into the grid.



Site	Monthly Total Capacity (TDS)	Annual Total Capacity (TDS)	End Product Quantity Per Year (TDS)	Operating Hours	FY20/21 Biogas Capacity [Nm3/hr]	REGO Biogas [Nm3/hr]*	Station TIC	FY 20-21 REGO Certs	FY 20-21 Average Load [MWe]	HHV (Average)
Avonmouth STW CHP Generation	3117	37,400	33,207	24/7	1657	446	5750	8478	1.17	3610
Berryhill STW	913	10,950	6944	24/7	346	76	900	1448	0.23	695
Poole STW CHP Generation	791	9,490	3788	24/7	189	120	1395	2282	0.24	742
Taunton STW CHP Generation	913	10,950	5689	24/7	284	188	850	3575	0.46	1404

cng services ltd

South West Water

South West Water have 5 active generating stations accredited with Ofgem under the Renewable Obligation. The Kilmington site has not been shown since the load and certificates claimed is very low and ended September 2020.

For the financial year of 2020/2021 South West Water claimed £0.229m from ROCs. This considerably less compared to the other water companies analysed in this report and is reflected from the electrical performance shown in the following page. The RO schemes for South West will end 2022 except for Totnes which will end a year later during 2023.

South West Water generated and used 4946MWh of electricity during the 2020/2021 financial year and generated and exported 1.6MWh of electricity to the grid. 11188MWh of electricity was required to be bought in from the grid or a third party.

5955MWh of heat was generated of which 3957MWh went unused.

South West Water did not produce or inject any biomethane during this period.

South West Water does not have advanced AD facility.

Accreditation Number	Generating Station	Station DNC	Accreditation Date	Commission Date	Generating Station Address
R00048RREN	Countess Wear STW CHP	660	01/01/2003	01/11/2002	Countess Wear STW CHP EX2 7AA
R00041RREN	Hayle STW CHP - D	335	01/04/2002	01/09/1996	Hayle STW CHP TR27 4RA
R00047RREN	Plympton STW CHP - C,D	270	01/04/2002	01/01/1998	Plympton STW CHP PL7 1YB
R00110RREN	Totnes STW CHP - D	105	01/12/2003	01/11/2003	Totnes STW CHP TQ9 5XN

South West Water – Site Data & Performance

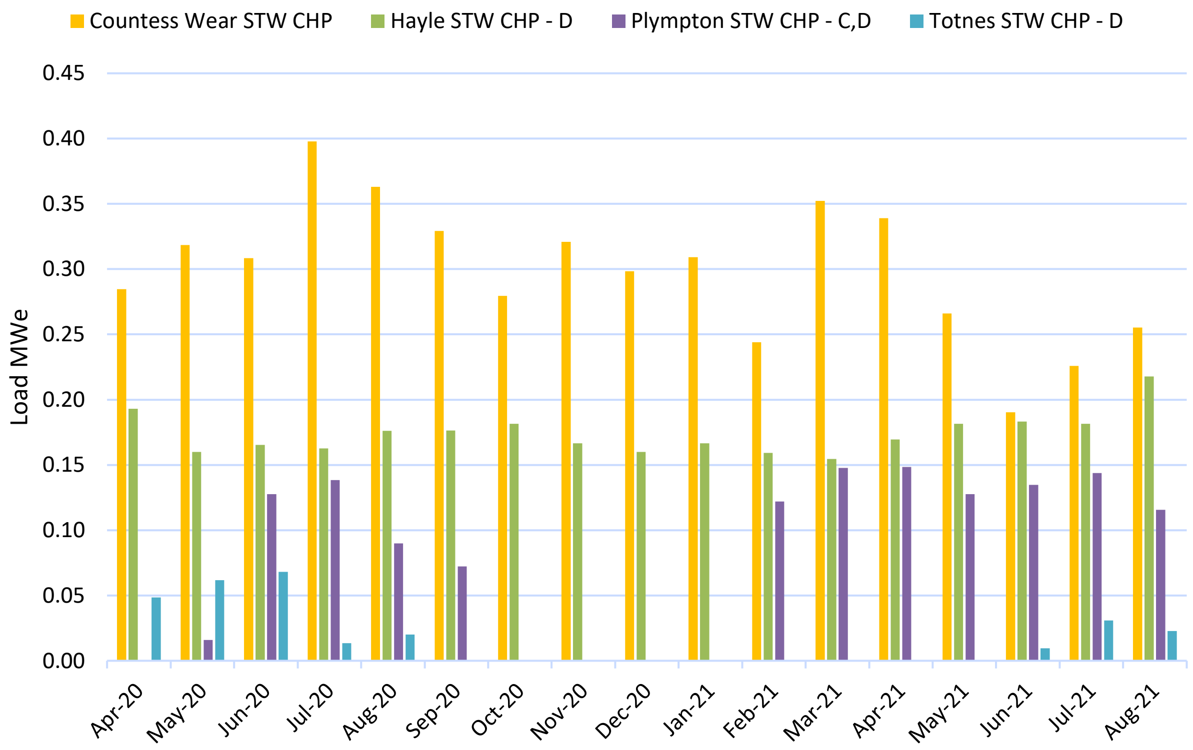
Electricity Generation

The graph to the right shows the hourly electricity loads for each month that the sites produce via biogas engines. The electricity load is generated from claimed certificates from Ofgem via the RO scheme and in general has the lowest average load.

Biogas Production [based upon market, public & private data]

From the table below, the sites use 40% to 89% of the total possible biogas production (FY20/21 Biogas Capacity) to run engines to generate electricity (REGO Biogas). Hayle is very efficient in biogas utilisation at 89% and has a very consistent electrical load pattern.

Totnes has the lowest biogas utilisation rate of 40% and is largely due to minimal sludge provided for the year, therefore leaving the periods of September 2020 to May 2021 without operation of the biogas engines.



Site	Monthly Total Capacity (TDS)	Annual Total Capacity (TDS)	End Product Quantity Per Year (TDS)	Operating Hours	FY20/21 Biogas Capacity [Nm3/hr]	REGO Biogas [Nm3/hr]*	Station TIC	FY 20-21 REGO Certs	FY 20-21 Average Load [MWe]	HHV (Average)
Countess Wear STW	439	5269	3807	Mon-Fri 08:00-16:00	190	146	660	2784	0.30	922
Hayle STW	325	3899	1299		87	78	335	1476	0.17	536
Plympton STW	121	1447	808		40	27	270	518	0.12	356
Totnes STW	157	1883	391		20	8	105	155	0.03	106

Site Suitability For Generator Conversion Summary

Northumbrian Water

Both Bran Sands and Howdon are currently accredited with the RHI and can upgrade biogas and inject biomethane into the grid. Currently all of Northumbrian Water's other sites are diverting sludge cake to these two sites.

Yorkshire Water

For Yorkshire Water, the Esholt facility is the optimal site for conversion as it has the largest sewage capacity as well as facility that accepts sewage on road by tankers. Although this could change should Yorkshire Water wish to refurbish the other sites or if other sites have a more economic and capacity for gas grid injection.

Welsh Water

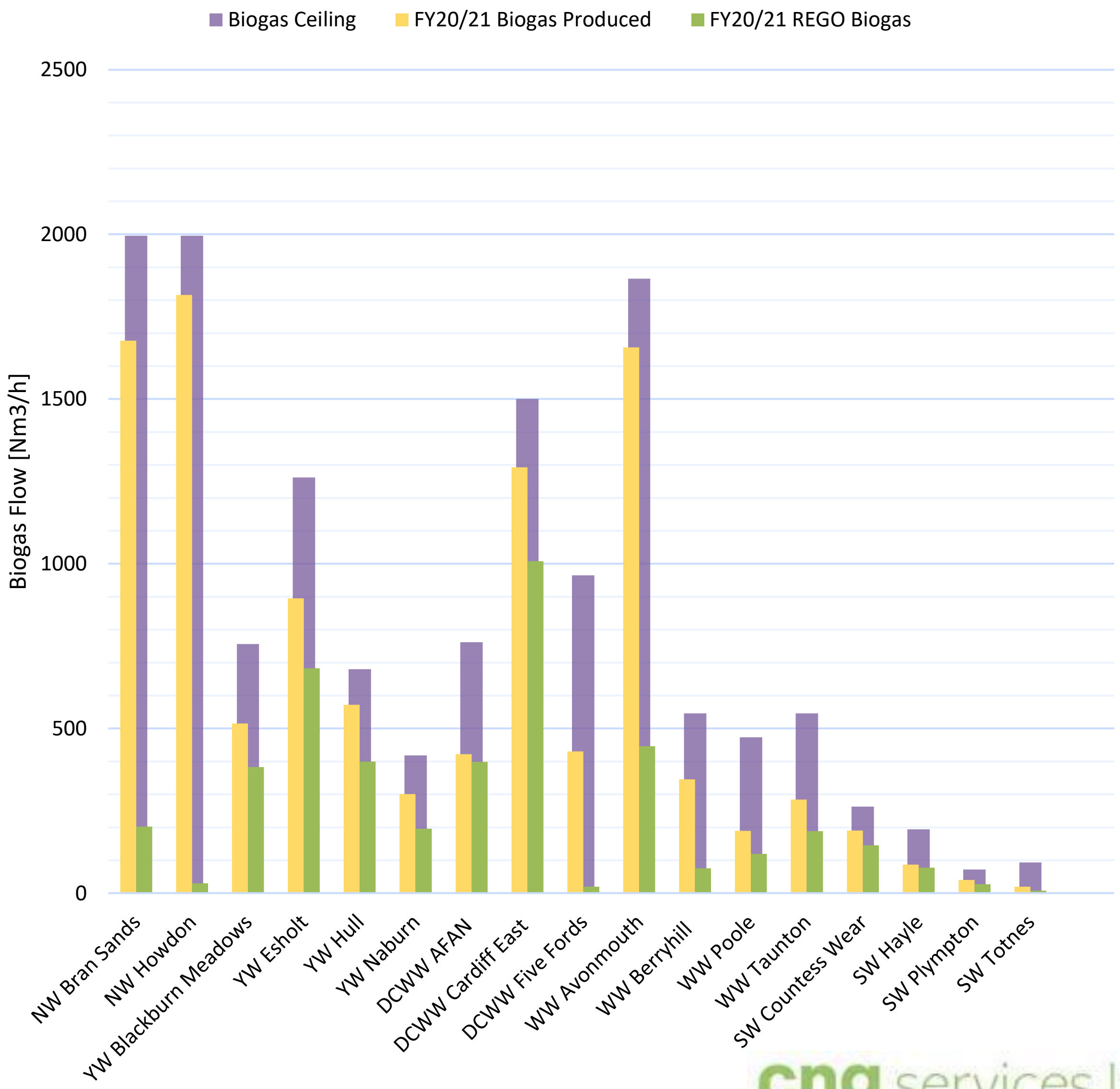
Five Fords is currently accredited with the RHI scheme leaving the Cardiff and Afan plants, both of which are very suitable given the sites total capacities and current capacities.

Wessex Water

Wessex Water are currently reviewing their bioresource strategy. Avonmouth is accredited with the RHI scheme. The Taunton site may increase in capacity since along with Avonmouth, is an advanced AD. The others are conventional AD or liming, so the Taunton site can potentially be suitable for conversion.

South West Water

Within the next two years the south west sites will lose their ROCs funds and are in a good position to consider the GGSS as it will assist in transitioning to advanced AD.



cng services ltd

Conversion Works

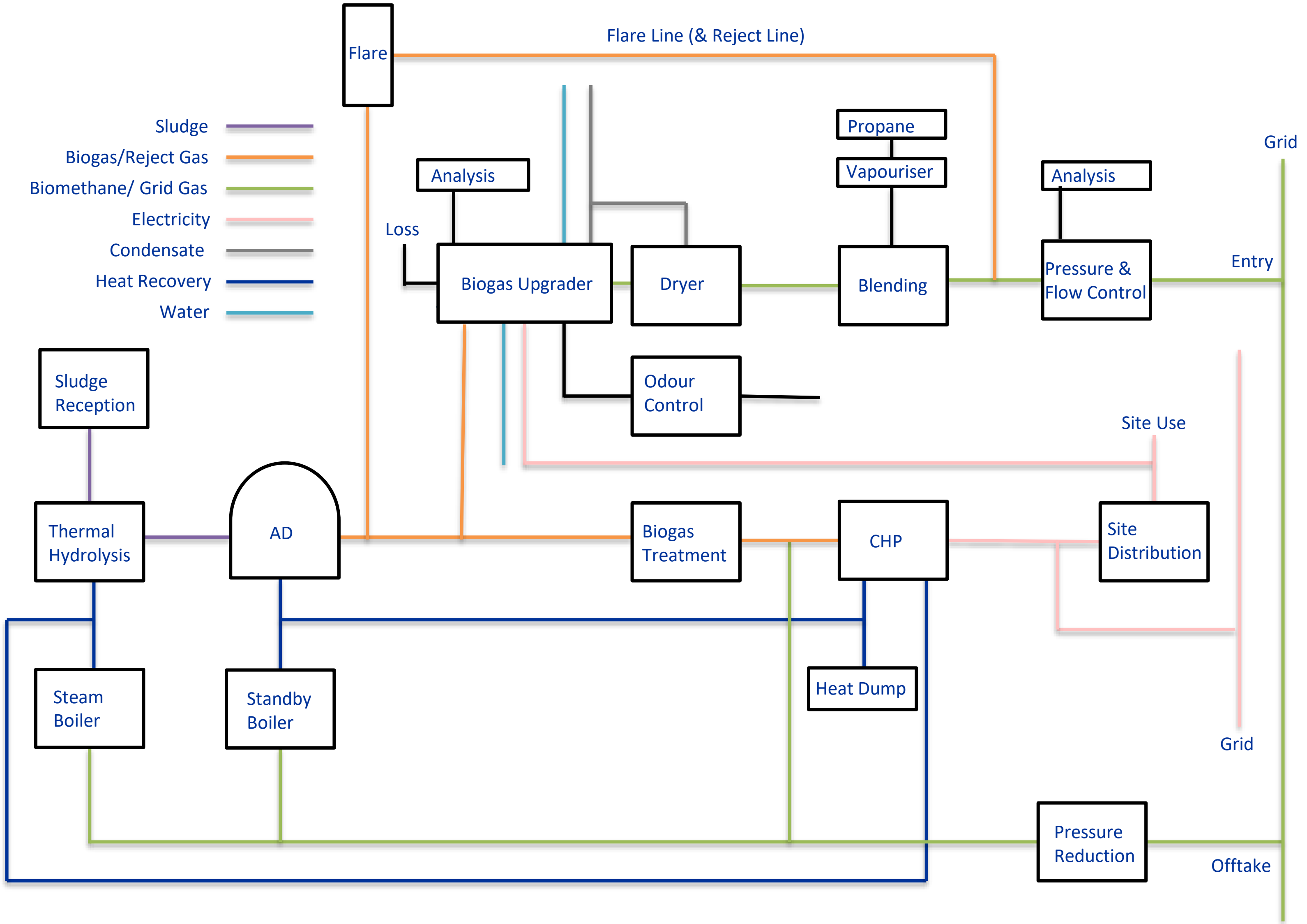
The general process for the required conversion works for the water companies AD sites to upgrade from biogas to biomethane is shown in the diagram to the right.

In principle the AD downstream systems are altered to allow clean-up and upgrade of biogas injecting it into the grid as biomethane. These are the works including the biogas upgrader to the grid entry point.

A connection to an existing flare unit for rejected gas will be required.

Biomethane and/or grid gas can be used to operate the CHP units at maximum output and boilers as necessary.

When the biomethane plant is down for maintenance, the CHPs can operate on biogas with the boiler fuelled with natural gas to make up heat.

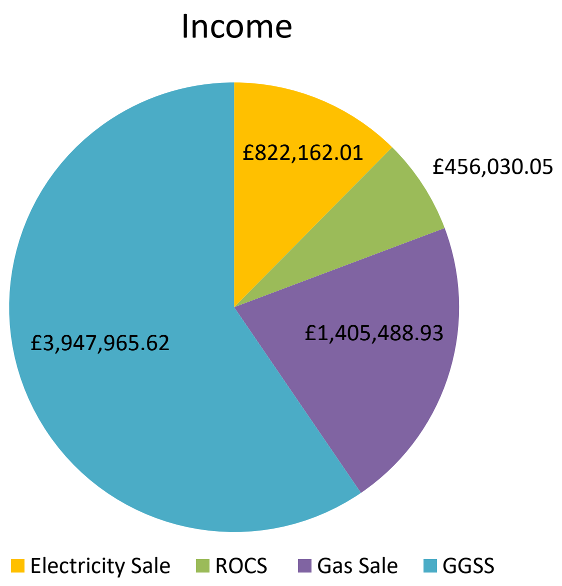


Financial Summary - Income

Income

For an approx. 30,000TDS sewage plant generating Biogas at rate of 1497Nm3/h the key income items are as shown in the pie chart below.

The pie chart below is based on two options are modelled. The first generates electricity and ROCS and the second injects biomethane and receives GGSS income. In principle the sale of biomethane is worth more than the sale of electricity due to a better efficiency as the generators will be approx. 40% efficient. Also the value of upgrading biogas to biomethane injecting it into the grid, claiming GGSS is significantly more than the value from ROCs. Again, there is a significantly lower loss with biomethane conversion than combusting biogas.

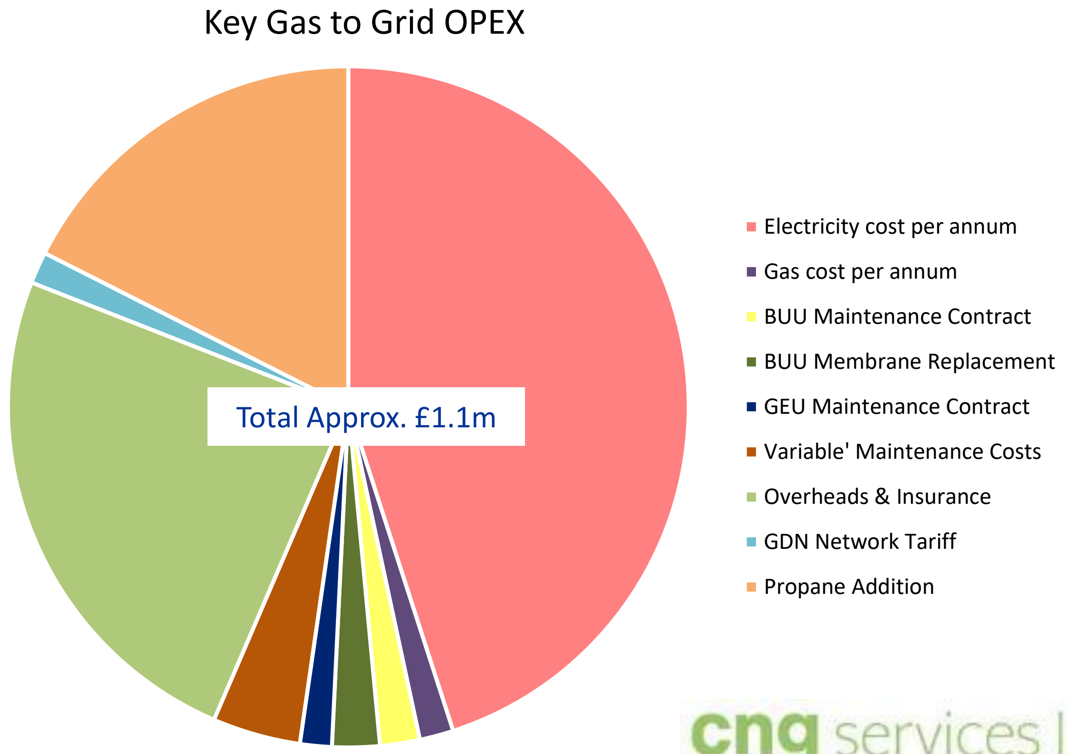


Option 1 = ROCS + Electricity Sale

Option 2 = GGSS + Gas Sale

Gas to Grid Conversion OPEX

The key OPEX items for a gas to grid conversion are shown below. Taking this into consideration the GGSS is still more economic compared to the ROCs (i.e. GGSS + Gas Sale - OPEX). However, in a non incentivised scenario with no GGSS or ROCS, the sale of electricity is more than the sale of gas when including the additional OPEX for gas to grid. This does not take into account the OPEX for electricity generation, downtimes for the biogas generators and is at a gas sale value of 1.67 p/kWh which is less than half of the 2022 gas price.



Financial Summary - CAPEX

Gas to Grid Conversion CAPEX

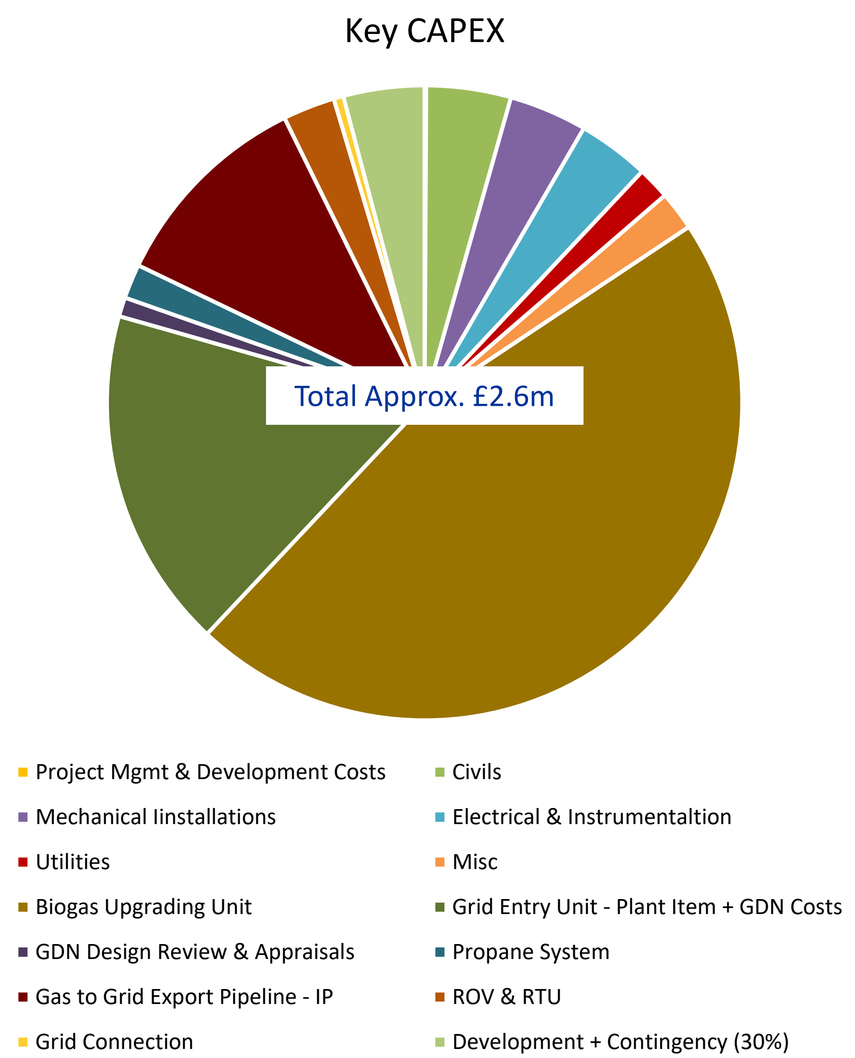
For the CAPEX of an approx. 30,000TDS sewage plant generating Biogas at rate of 1497Nm3/h the key items are as shown in the pie chart to the right. The total CAPEX required is approximately £2.6m.

The required funding is less than normal since the AD facility already exists which is the leading item for such facility. Given the value of the GGSS and the absence of the AD the CAPEX can be financed within a year if chosen to do so.

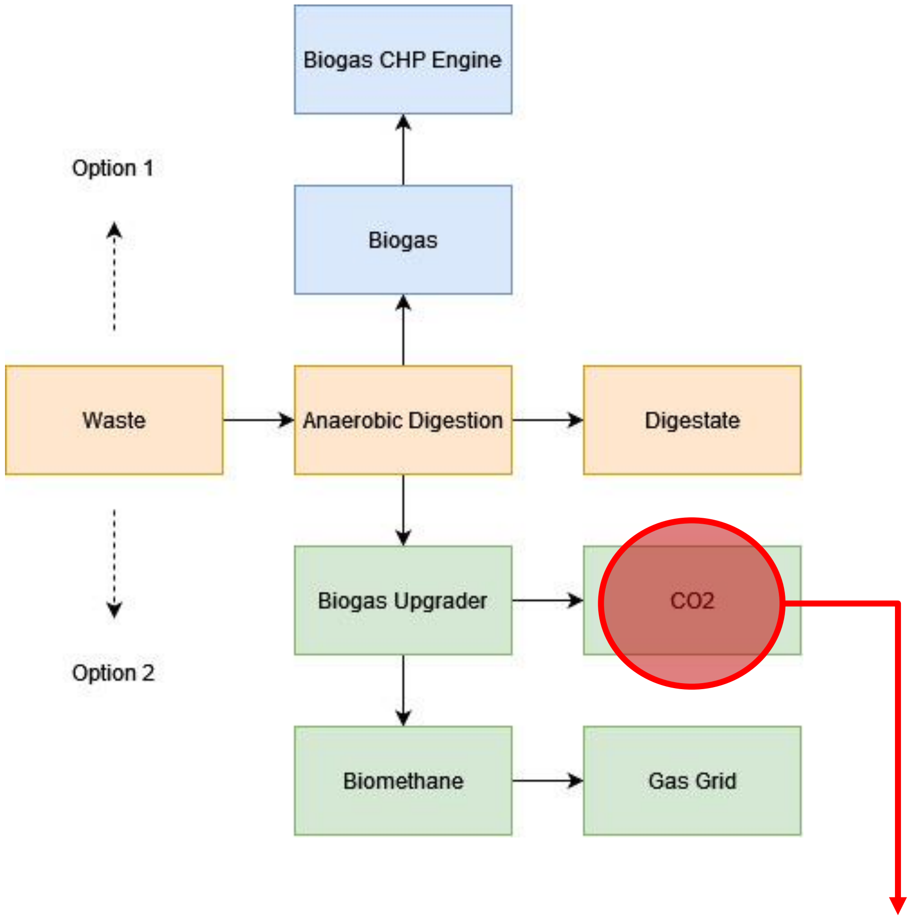
A CHP generator costs about 10% of the shown gas to grid CAPEX and is significantly cheaper and easier to set up if not done so.

Assumptions

- Access and available capacity for an MP grid connection requiring 1km of pipeline.
- It is assumed that since AD's can have access for a gas offtake connection for heat this would a reasonable assumption and therefore;
- also not require compressors to inject gas into the MP grid.
- Electricity import and export costs of 11.05 p/kWh and 4.25 p/kWh respectively.
- Gas basic sales value of 1.67 p/kWh.
- GGSS values of 5.51 p/kWh (Tier 1), 3.53 p/kWh (Tier 2) and 1.56 p/kWh (Tier 3).
- The financial year of 2020-2021 was used for the value of ROCs and buyout price



Environmental Impacts



During the biogas upgrading process **almost all of the CO_2 can be captured** and reused or permanently removed from the atmosphere and sent to CCS. This leads to significant CO_2 emission since approximately 40% of sewage biogas is CO_2.

CHP Load Patterns

Depending on the facility and mode of operation the CHP load patterns vary from site to site. In general, the optimal load pattern is to run the engines at full load (100%) at specific intervals when needed (i.e. 4 hours per day). If the engines are run over longer periods of time but at a continuous partial load (i.e. 60%-80%) there is a relative CO_2 emission increase. This occurs due to diminishing engine efficiency as load decreases and therefore requiring more biogas input.

CHP run from grid gas or biomethane upgraded from the site is a better fuel input since it generates more energy per unit load as biomethane has a higher energy content compared to biogas. Also approximately 40% of sewage biogas is CO_2 which is captured in the biogas upgrading process.

Flared & Uncaptured Biogas

Currently, sewage AD sites that do not have grid injection capacity flare excess biogas. This is essentially combusting biogas into the atmosphere since it cannot be stored and has to be done since the AD sewage waste will continue to generate biogas which is a dangerous and flammable fuel.

Biogas CHP engines can require significant maintenance downtimes during which the generated biogas is flared and natural gas from the grid is bought in to generate heat for the AD processes.

In the proposed conversion flaring will be minimal to zero under competent operation as all the upgraded biogas, biomethane can be injected into the gas grid.

Barriers, Challenges & Opportunity

Advanced Anaerobic Digestion Opportunity

The advised industry best practice for sewage gas AD is akin to the Northumbrian water model briefly mentioned in this report. This is transitioning from conventional AD to advanced AD and centralising them so other facilities divert sewage waste, sustaining the AD at maximum capacity, maintaining optimal efficiency and other commercial sewage industry benefits. This ultimately allows the facilities to capture the maximum amount of biogas from sewage waste possible. These facilities then upgrade biogas to biomethane and inject it into the grid. Natural gas and biomethane in turn used as the heating fuel which is cleaner and less abrasive to mechanical equipment.

South West Water can benefit the most from this as they currently do not have an operational advanced AD facility. The upgrade along with a biomethane connection can provide them with a very good business case when applying for the GGSS as the tariff benefits can finance the CAPEX and provide further financial (and environmental) incentives.

Gas Capacity Restriction

Biomethane needs to be injected into the grid to benefit from the GGSS financial incentive. If gas is not being injected the tariff is not paid. Should the local or nearest network not have capacity or a demand there are other options available that will allow the water company to continue biomethane injection. The options include an alternative high pressure connection, use of gas trailers as part of a central hub or a reverse compression connection, which will allow the water company to use the previously constrained gas network.

The scope of the gas capacity is explored in the stage 1 report conducted as part of this research project.

Maintenance of Biogas vs Biomethane run CHP

Biomethane and natural gas is a better fuel for CHP than the use of biogas. Biomethane has more energy content and combusts better. Sewage biogas can contain water vapour which affects the combustion and even at low moisture content, reduces the efficiency of the CHP system. Above a certain moisture level biogas combustion becomes a challenge.

Hydrogen sulphide (H2S) is derived as a by-product of the AD process of sulphur feedstocks. Hydrogen sulphide can condense with water during combustion to form sulphuric acid which naturally is corrosive and has a very adverse effect on the engines. This leads to an increase in maintenance times as well as safety risk.

Sewage biogas can contain siloxanes which can react with oxygen and other elements during combustion. This leaves mineral deposits in the machinery which needs to be removed chemically or mechanically.

GGSS vs RO

The financial value of the GGSS is better per MWh of energy compared to the RO scheme. While the finance is not significantly different i.e. a 6% financial increase below 60GWh the water companies can expect a continue to the added revenue if they have sites whose RO scheme is ending. The AD site upgrades completed for the GGSS will lead to benefits to the operation as a whole with reduced maintenance times and a reduction in the amount of flared gas.

Conclusion

In conclusion it is financially and technically better for water companies to upgrade from ageing AD, from conventional/liming to advanced AD. Companies who currently do not have such facility and whose RO scheme is ending such as South West Water can benefit from using the GGSS to assist in the upgrade.

Companies who already have advanced AD facility can benefit from the GGSS* and inject biomethane in to the gas grid due to the following:

1. The raw financial value of the GGSS is more than the current value from the RO scheme.
2. Upgrading biogas to biomethane captures a significant amount of CO2 which can be permanently removed from the atmosphere.
3. Biomethane run CHP has better performance and requires less maintenance compared to biogas run CHP. Generator companies can easily facilitate the change in fuel (as sewage biogas already consists of approx. 60% CH4).
4. Competent operation can lead to zero amount of fuel being flared. Biogas and biomethane are a much worse greenhouse gas compare to raw CO2.

The technically feasible of the conversion from biogas CHP to biomethane injection has no major technical challenges with plenty of industry experience, competence and successes in the UK. Water companies who have made the switch have found success such as Northumbrian Water who have now made the conversion to both of the two primary sewage AD sites.

*Note. Companies can get GGSS if they are expanding with new AD capacity, biomethane plant, pipeline etc. Existing facilities that are not expanding cannot get GGSS but can earn RTFC.

Appendix A – General Generator Sensitivity

Distribution of the Declared Net Capacity

There are 174 sewage gas generating stations accredited and listed on the Ofgem public register:

- The smallest being 30 kW.
- The largest individual station is 11600 kW.
- The largest single generator on the other hand is 2450 kW.
- The average Jenbacher and MWM generator size 1020 kW and 1387 kW respectively.

Overall, based on the total capacity installed across the sector, and the number of operating locations producing accredited output, the average load factors (asset run load compared to installed capacity) appears lower than would be expected for a strong commercial operation.

With over 207MWe of DNC listed, achieving an average availability of 90% (7884 hours per annum), and full fuel availability, the sector would be expected to generate over 1.6 M MWh annually. The average number of certificates issued over the past 5 years for the sector is a little under 0.693 M MWh, producing a load factor of approximately 37%.

Larger sites, with a higher level of Biogas production, could be expected to install more capacity than the fuel available will support at baseload, ensuring that plant is available to use all gas produced. The consistency of generation volume across the sector during the past 5 years suggests that this may be counter intuitive, as variability of production at individual locations is significant, and therefore other operational factors are likely to be influencing outputs.

Sensitivity – Installed Capacity and Operation

Generator performance is materially impacted by :

- Average sustained load - Higher loads increase the Break Mean Effective Pressure (BMEP), and enable more efficient operation.
- Maintenance programme - Good maintenance plans and programmes improve operational load, availability and efficiency.

Therefore, understanding the operational performance of the installations is key to determining the likely overall performance.

Appendix B – Generator Sensitivity Statistics

Individual Site Assessments

A small sample of locations has been used to further investigate behaviour and output patterns. The distribution of capacity has been used to drive the selection process, with 3 sites of below average size (typically single engine installations), 3 sites of around the average capacity, and 3 sites of larger capacity.

Based on the Declared Net Capacity (DNC) the distribution is as follows:

- Sub 500 kW installations 17.6 MW 8.3% of total
- 500 kW to 1000 kW 25.5 MW 12.1% of total
- 1000 kW to 2000 kW 41.8 MW 19.8% of total
- 2000 kW to 4000 kW 54 MW 25.6% of total
- Above 4000 kW 72.4 MW 34.3% of total

The sub 500 kW sites tend to be single engine locations, and therefore the output reflects the true underlying performance of the site, without overcapacity providing cover and facilitating operational rotation. Average and larger sites are typically multi generator operations, and therefore could support a duty standby operating pattern, which would distort analysis.

Applying this logic, an observer might expect single engine sites, requiring high uptime to convert available fuel, to outperform the larger locations where equipment may be stood down. Whilst one or two locations deliver the expected (higher) performance, other sites align with the sector averages.

In summary the Sewage Gas Generation Sector is distributed as follows:

- Overall average installation size 1191 kW (DNC)
- Total number of accredited stations 174
- Stations below 500 kW 76 (44%)
- Stations below 1000 kW 114 (66%)
- Stations below 2000 kW 145 (83%)

Impact on Performance

Assuming that the sample sites are representative of the overall performance, albeit that the sample average load factor is significantly higher that the overall sector average, the sewage gas sector appears to operate with low asset utilisation, which will affect efficiency. As there is large month to month variability in output at individual sites it also appears likely that a number of locations suffer from low mechanical availability, which may result in flaring of the Biogas produced.

The general sector performance suggests that conversion efficiency is likely to be low, and could easily be sub 35%, which would in turn make the production of Biomethane more attractive.

The distribution of scale is however less favourable, as a large number (114) of locations have an installed capacity of <1MW, and if operated at full load would convert approx. 475 m3/hr (at 60% methane) – which would produce approx. 260 m3/hr of Biomethane.

The development of a small modular system, with the benefit of a mass production approach, could be key to delivering a commercially viable solution at the scale of operation likely to be required to deliver maximum benefit.

Appendix C – Site Load Tables

Northumbrian Water – 1

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G01292SGEN	Bran Sands (RSTC Advanced Digestion) Facility	4771	REGO	Sep-21	392	0.54	2124
				Aug-21	433	0.58	
				Jul-21	69	0.09	
				Jun-21	688	0.96	
				May-21	219	0.29	
				Apr-21	323	0.45	
				Mar-21	180	0.24	3843
				Feb-21	94	0.14	
				Jan-21	510	0.69	
				Dec-20	75	0.10	
				Nov-20	1127	1.57	
				Oct-20	460	0.62	
				Sep-20	599	0.83	
				Aug-20	414	0.56	
				Jul-20	40	0.05	
				Jun-20	274	0.38	
				May-20	50	0.07	
				Apr-20	20	0.03	
				Min	20	0.03	
				Max	1127	1.57	
				Average	332	0.455	

Parameter	Value	Unit
Average load (vs time)	0.455	MWe
Load Factor (vs capacity)	41	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	1210	kWh th / h
Correction for losses and ineligible loads	1287	kWh th / h
Average HHV of fuel for generation	1403	kWh th / h

Northumbrian Water – 2

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
				Sep-21	76	0.11		Average load (vs time)	0.209	MWe
				Aug-21	189	0.25		Load Factor (vs capacity)	19	%
				Jul-21	327	0.44	1412	Adjusted Efficiency	37.6	%
				Jun-21	793	1.10		Average LHV of fuel for generation	555	kWh th / h
				May-21	12	0.02		Correction for losses and ineligible loads	591	kWh th / h
				Apr-21	15	0.02		Average HHV of fuel for generation	644	kWh th / h
G01313SGEN	Howdon AAD	6000	REGO	Feb-21	11	0.02				
				Jan-21	9	0.01				
				Dec-20	2	0.003				
				Nov-20	52	0.07	566			
				Oct-20	223	0.30				
				Jul-20	7	0.01				
				Jun-20	262	0.36				
				Min	2	0.003				
				Max	793	1.10				
				Average	152	0.21				

Yorkshire Water – 1

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00847SGEN	Aldwarke WWTW - D	471	REGO	Aug-21	151	0.20	1026
				Jul-21	202	0.27	
				Jun-21	234	0.33	
				May-21	205	0.28	
				Apr-21	234	0.33	
				Mar-21	173	0.23	1996
				Feb-21	69	0.10	
				Jan-21	150	0.20	
				Dec-20	133	0.18	
				Nov-20	196	0.27	
				Oct-20	115	0.15	
				Sep-20	182	0.25	
				Aug-20	141	0.19	
				Jul-20	216	0.29	
				Jun-20	211	0.29	
				May-20	186	0.25	
				Apr-20	224	0.31	
				Min	69	0.10	
				Max	234	0.33	
				Average	178	0.24	

Parameter	Value	Unit
Average load (vs time)	0.24	MWe
Load Factor (vs capacity)	22	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	646	kWh th / h
Correction for losses and ineligible loads	687	kWh th / h
Average HHV of fuel for generation	749	kWh th / h

Yorkshire Water – 2

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G01315SGEN	Blackburn Meadows STW CHP	2000	REGO	Aug-21	1079	1.45	4666
				Jul-21	1216	1.63	
				Jun-21	1013	1.41	
				May-21	738	0.99	
				Apr-21	620	0.86	
				Mar-21	1224	1.65	7281
				Feb-21	596	0.89	
				Jan-21	871	1.17	
				Dec-20	1255	1.69	
				Nov-20	1122	1.56	
				Sep-20	101	0.14	
				Aug-20	1113	1.50	
				Jul-20	607	0.82	
				Jun-20	104	0.14	
				May-20	2	0.003	
				Apr-20	286	0.40	
				Min	2	0.00	
				Max	1255	1.69	
				Average	747	1.02	

Parameter	Value	Unit
Average load (vs time)	1.02	MWe
Load Factor (vs capacity)	93	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	2708	kWh th / h
Correction for losses and ineligible loads	2880	kWh th / h
Average HHV of fuel for generation	3140	kWh th / h

Yorkshire Water – 3

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G01257SGEN	Bridlington CHP	190	REGO	Aug-21	58	0.08	261
				Jul-21	58	0.08	
				Jun-21	58	0.08	
				May-21	63	0.08	
				Apr-21	24	0.03	
				Mar-21	63	0.08	649
				Feb-21	52	0.08	
				Jan-21	21	0.03	
				Dec-20	77	0.10	
				Nov-20	71	0.10	
				Oct-20	43	0.06	
				Sep-20	67	0.09	
				Aug-20	79	0.11	
				Jul-20	64	0.09	
				Jun-20	28	0.04	
				May-20	37	0.05	
				Apr-20	47	0.07	
				Min	21	0.03	
				Max	79	0.11	
				Average	54	0.07	

Parameter	Value	Unit
Average load (vs time)	0.07	MWe
Load Factor (vs capacity)	7	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	195	kWh th / h
Correction for losses and ineligible loads	207	kWh th / h
Average HHV of fuel for generation	226	kWh th / h

Yorkshire Water – 4

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00659SGEN	Calder Vale WWTW - A,C,D	440	REGO	Aug-21	224	0.30	1101
				Jul-21	200	0.27	
				Jun-21	234	0.33	
				May-21	240	0.32	
				Apr-21	203	0.28	
				Mar-21	225	0.30	2301
				Feb-21	165	0.25	
				Jan-21	195	0.26	
				Dec-20	192	0.26	
				Nov-20	154	0.21	
				Oct-20	147	0.20	
				Sep-20	204	0.28	
				Aug-20	211	0.28	
				Jul-20	235	0.32	
				Jun-20	155	0.22	
				May-20	197	0.26	
				Apr-20	221	0.31	
				Min	147	0.20	
				Max	240	0.33	
				Average	200	0.27	

Parameter	Value	Unit
Average load (vs time)	0.27	MWe
Load Factor (vs capacity)	25	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	727	kWh th / h
Correction for losses and ineligible loads	774	kWh th / h
Average HHV of fuel for generation	843	kWh th / h

cng services ltd

Yorkshire Water – 5

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
				Aug-21	1422	1.91		Average load (vs time)	1.63	Mwe
				Jul-21	1168	1.57		Load Factor (vs capacity)	74	%
				Jun-21	1337	1.86	7321	Adjusted Efficiency	37.6	%
				May-21	1802	2.42		Average LHV of fuel for generation	4335	kWh th / h
				Apr-21	1592	2.21		Correction for losses and ineligible loads	4611	kWh th / h
				Mar-21	1344	1.81		Average HHV of fuel for generation	5026	kWh th / h
				Feb-21	816	1.21				
				Jan-21	816	1.10				
G01258SGEN	Esholt STW CHP	4344	REGO	Dec-20	955	1.28				
				Nov-20	436	0.61				
				Oct-20	1008	1.35	12982			
				Sep-20	431	0.60				
				Aug-20	1090	1.47				
				Jul-20	1440	1.94				
				Jun-20	1274	1.77				
				May-20	1741	2.34				
				Apr-20	1631	2.27				
				Min	431	0.60				
				Max	1802	2.42				
				Average	1194	1.63				

Yorkshire Water – 6

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
G00656SGEN	Ewden WTW - A,D	275	REGO	Jun-21	33	0.05	192	Average load (vs time)	0.10	MWe
				May-21	73	0.10		Load Factor (vs capacity)	9	%
				Apr-21	86	0.12		Adjusted Efficiency	37.6	%
				Mar-21	93	0.13	925	Average LHV of fuel for generation	272	kWh th / h
				Feb-21	80	0.12		Correction for losses and ineligible loads	289	kWh th / h
				Jan-21	97	0.13		Average HHV of fuel for generation	315	kWh th / h
				Dec-20	89	0.12				
				Nov-20	79	0.11				
				Oct-20	59	0.08				
				Sep-20	58	0.08				
				Aug-20	42	0.06				
				Jul-20	77	0.10				
				Jun-20	74	0.10				
				May-20	91	0.12				
				Apr-20	86	0.12				
				Min	33	0.05				
				Max	97	0.13				
				Average	74	0.10				

Yorkshire Water – 7

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G01256SGEN	Hull WWTW CHPs	1503	REGO	Aug-21	909	1.22	3715
				Jul-21	692	0.93	
				Jun-21	585	0.81	
				May-21	742	1.00	
				Apr-21	787	1.09	
				Mar-21	799	1.07	7615
				Feb-21	574	0.85	
				Jan-21	602	0.81	
				Dec-20	528	0.71	
				Nov-20	323	0.45	
				Oct-20	537	0.72	
				Sep-20	543	0.75	
				Aug-20	597	0.80	
				Jul-20	645	0.87	
				Jun-20	763	1.06	
				May-20	857	1.15	
				Apr-20	847	1.18	
				Min	323	0.45	
				Max	909	1.22	
				Average	666	0.91	

Parameter	Value	Unit
Average load (vs time)	0.91	MWe
Load Factor (vs capacity)	83	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	2422	kWh th / h
Correction for losses and ineligible loads	2577	kWh th / h
Average HHV of fuel for generation	2809	kWh th / h

Yorkshire Water – 8

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
G00657SGEN	Loxley WTW - A,D,E	220	REGO	Aug-21	71	0.10	246	Average load (vs time)	0.08	MWe
				Jul-21	37	0.05		Load Factor (vs capacity)	7	%
				Jun-21	36	0.05		Adjusted Efficiency	37.6	%
				May-21	24	0.03		Average LHV of fuel for generation	213	kWh th / h
				Apr-21	78	0.11		Correction for losses and ineligible loads	227	kWh th / h
				Mar-21	30	0.04	748	Average HHV of fuel for generation	247	kWh th / h
				Feb-21	74	0.11				
				Jan-21	68	0.09				
				Dec-20	68	0.09				
				Nov-20	71	0.10				
				Oct-20	67	0.09				
				Sep-20	64	0.09				
				Aug-20	71	0.10				
				Jul-20	67	0.09				
				Jun-20	29	0.04				
				May-20	64	0.09				
				Apr-20	75	0.10				
				Min	24	0.03				
				Max	78	0.11				
				Average	58	0.08				

Yorkshire Water – 9

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
G00660SGEN	Lundwood WWTW A, C, D	165	REGO	Aug-21	47	0.06	306	Average load (vs time)	0.11	MWe
				Jul-21	58	0.08		Load Factor (vs capacity)	10	%
				Jun-21	18	0.03		Adjusted Efficiency	37.6	%
				May-21	85	0.11		Average LHV of fuel for generation	284	kWh th / h
				Apr-21	98	0.14		Correction for losses and ineligible loads	302	kWh th / h
				Mar-21	78	0.10	1021	Average HHV of fuel for generation	329	kWh th / h
				Feb-21	64	0.10				
				Jan-21	83	0.11				
				Dec-20	62	0.08				
				Nov-20	79	0.11				
				Oct-20	79	0.11				
				Sep-20	99	0.14				
				Aug-20	99	0.13				
				Jul-20	98	0.13				
				Jun-20	93	0.13				
				May-20	91	0.12				
				Apr-20	96	0.13				
				Min	18	0.03				
				Max	99	0.14				
				Average	78	0.11				

Yorkshire Water – 10

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00661SGEN	Mitchell Laithes WWTC - A,C,D	1332	REGO	Aug-21	197	0.26	1578
				Jul-21	361	0.49	
				Jun-21	398	0.55	
				May-21	313	0.42	
				Apr-21	309	0.43	
				Mar-21	294	0.40	1259
				Feb-21	1	0.001	
				Feb-21	165	0.25	
				Jan-21	262	0.35	
				Dec-20	351	0.47	
				Nov-20	186	0.26	
				Min	1	0.001	
				Max	398	0.55	
				Average	258	0.35	

Parameter	Value	Unit
Average load (vs time)	0.35	MWe
Load Factor (vs capacity)	32	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	937	kWh th / h
Correction for losses and ineligible loads	997	kWh th / h
Average HHV of fuel for generation	1087	kWh th / h

cng services ltd

Yorkshire Water – 11

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00667SGEN	Naburn WWTW	612	REGO	Aug-21	230	0.31	1506
				Jul-21	282	0.38	
				Jun-21	296	0.41	
				May-21	396	0.53	
				Apr-21	302	0.42	
				Mar-21	330	0.44	3730
				Feb-21	283	0.42	
				Jan-21	282	0.38	
				Dec-20	276	0.37	
				Nov-20	346	0.48	
				Oct-20	342	0.46	
				Sep-20	266	0.37	
				Aug-20	271	0.36	
				Jul-20	301	0.40	
				Jun-20	259	0.36	
				May-20	376	0.51	
				Apr-20	398	0.55	
				Min	230	0.31	
				Max	398	0.55	
				Average	308	0.42	

Parameter	Value	Unit
Average load (vs time)	0.42	MWe
Load Factor (vs capacity)	38	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	1120	kWh th / h
Correction for losses and ineligible loads	1192	kWh th / h
Average HHV of fuel for generation	1299	kWh th / h

Yorkshire Water – 12

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00662SGEN	Old Whittington WWTC - A C D	612	REGO	Aug-21	262	0.35	1604
				Jul-21	363	0.49	
				Jun-21	311	0.43	
				May-21	332	0.45	
				Apr-21	336	0.47	
				Mar-21	269	0.36	3423
				Feb-21	190	0.28	
				Jan-21	296	0.40	
				Dec-20	233	0.31	
				Nov-20	310	0.43	
				Oct-20	313	0.42	
				Sep-20	253	0.35	
				Aug-20	228	0.31	
				Jul-20	267	0.36	
				Jun-20	347	0.48	
				May-20	375	0.50	
				Apr-20	342	0.48	
				Min	190	0.28	
				Max	375	0.50	
				Average	296	0.40	

Parameter	Value	Unit
Average load (vs time)	0.40	MWe
Load Factor (vs capacity)	37	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	1075	kWh th / h
Correction for losses and ineligible loads	1143	kWh th / h
Average HHV of fuel for generation	1246	kWh th / h

cng services ltd

Yorkshire Water – 13

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00663SGEN	Sandall (WwTW) - A,C,D,E	507	REGO	Aug-21	174	0.23	940
				Jul-21	231	0.31	
				Jun-21	225	0.31	
				May-21	150	0.20	
				Apr-21	160	0.22	
				Mar-21	290	0.39	2447
				Feb-21	220	0.33	
				Jan-21	222	0.30	
				Dec-20	217	0.29	
				Nov-20	172	0.24	
				Oct-20	229	0.31	
				Sep-20	206	0.29	
				Aug-20	200	0.27	
				Jul-20	168	0.23	
				Jun-20	91	0.13	
				May-20	173	0.23	
				Apr-20	259	0.36	
				Min	91	0.13	
				Max	290	0.39	
				Average	199	0.27	

Parameter	Value	Unit
Average load (vs time)	0.27	MWe
Load Factor (vs capacity)	25	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	725	kWh th / h
Correction for losses and ineligible loads	771	kWh th / h
Average HHV of fuel for generation	841	kWh th / h

Yorkshire Water – 14

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00666SGEN	Woodhouse WWTW - A, C, D	500	REGO	Aug-21	223	0.30	1077
				Jul-21	139	0.19	
				Jun-21	217	0.30	
				May-21	276	0.37	
				Apr-21	222	0.31	
				Mar-21	194	0.26	2520
				Feb-21	174	0.26	
				Jan-21	175	0.24	
				Dec-20	194	0.26	
				Nov-20	239	0.33	
				Oct-20	182	0.24	
				Sep-20	197	0.27	
				Aug-20	198	0.27	
				Jul-20	205	0.28	
				Jun-20	237	0.33	
				May-20	278	0.37	
				Apr-20	247	0.34	
				Min	139	0.19	
				Max	278	0.37	
				Average	212	0.29	

Parameter	Value	Unit
Average load (vs time)	0.29	MWe
Load Factor (vs capacity)	26	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	770	kWh th / h
Correction for losses and ineligible loads	819	kWh th / h
Average HHV of fuel for generation	893	kWh th / h

Welsh Water – 1

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G01140SGWA	AFAN WWTW CHP	3072	REGO	Sep-21	1114	1.55	7391
				Aug-21	1380	1.85	
				Jul-21	938	1.26	
				Jun-21	1086	1.51	
				May-21	1418	1.91	
				Apr-21	1455	2.02	
				Mar-21	482	0.65	7585
				Feb-21	240	0.36	
				Jan-21	453	0.61	
				Dec-20	569	0.76	
				Nov-20	456	0.63	
				Oct-20	554	0.74	
				Sep-20	796	1.11	
				Aug-20	854	1.15	
				Jul-20	872	1.17	
				Jun-20	767	1.07	
				May-20	739	0.99	
				Apr-20	803	1.12	
				Min	240	0.36	
				Max	1455	2.02	
				Average	832	1.14	

Parameter	Value	Unit
Average load (vs time)	1.14	MWe
Load Factor (vs capacity)	50.1	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	3022	kWh th / h
Correction for losses and ineligible loads	3215	kWh th / h
Average HHV of fuel for generation	3504	kWh th / h

Welsh Water – 2

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
G01141SGWA	Cardiff East WWTW CHP	4200	REGO	Sep-21	844	1.17	7575	Average load (vs time)	2.03	MWe
				Aug-21	776	1.04		Load Factor (vs capacity)	92.5	%
				Jul-21	927	1.25		Adjusted Efficiency	37.6	%
				Jun-21	1371	1.90		Average LHV of fuel for generation	5412	kWh th / h
				May-21	1872	2.52		Correction for losses and ineligible loads	5757	kWh th / h
				Apr-21	1785	2.48		Average HHV of fuel for generation	6275	kWh th / h
				Mar-21	1634	2.20	19171			
				Feb-21	1334	1.99				
				Jan-21	1480	1.99				
				Dec-20	1008	1.35				
				Nov-20	1401	1.95				
				Oct-20	1714	2.30				
				Sep-20	1620	2.25				
				Aug-20	1463	1.97				
				Jul-20	1610	2.16				
				Jun-20	1922	2.67				
				May-20	2115	2.84				
				Apr-20	1870	2.60				
				Min	776	1.04				
				Max	2115	2.84				
				Average	1486	2.03				

Welsh Water – 3

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G01145SGWA	Five Fords WWTW CHP	1200	REGO	Apr-21	6	0.01	6
				Mar-21	4	0.01	380
				Feb-21	90	0.13	
				Jan-21	51	0.07	
				Dec-20	23	0.03	
				Nov-20	11	0.02	
				Oct-20	60	0.08	
				Sep-20	18	0.03	
				Aug-20	14	0.02	
				Jul-20	35	0.05	
				Jun-20	26	0.04	
				May-20	18	0.02	
				Apr-20	30	0.04	
				Min	4	0.01	
				Max	90	0.13	
				Average	30	0.04	

Parameter	Value	Unit
Average load (vs time)	0.04	MWe
Load Factor (vs capacity)	4	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	110	kWh th / h
Correction for losses and ineligible loads	117	kWh th / h
Average HHV of fuel for generation	127	kWh th / h

Welsh Water – 4

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
G01319SGEN	Trowbridge STW New CHP	1166	REGO	Mar-21	5	0.01	92	Average load (vs time)	0.01	MWe
				Feb-21	6	0.01		Load Factor (vs capacity)	1	%
				Jan-21	56	0.08		Adjusted Efficiency	37.6	%
				Dec-20	2	0.00		Average LHV of fuel for generation	37	kWh th / h
				Nov-20	5	0.01		Correction for losses and ineligible loads	39	kWh th / h
				Oct-20	12	0.02		Average HHV of fuel for generation	43	kWh th / h
				Sep-20	4	0.01				
				Aug-20	1	0.00				
				May-20	1	0.00				
				Min	1	0.001				
				Max	56	0.08				
				Average	10	0.01				

South West Water – 1

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00415SGEN	Countess Wear STW CHP	660	REGO	Aug-21	190	0.26	937
				Jul-21	168	0.23	
				Jun-21	137	0.19	
				May-21	198	0.27	
				Apr-21	244	0.34	
				Mar-21	262	0.35	2784
				Feb-21	164	0.24	
				Jan-21	230	0.31	
				Dec-20	222	0.30	
				Nov-20	231	0.32	
				Oct-20	208	0.28	
				Sep-20	237	0.33	
				Aug-20	270	0.36	
				Jul-20	296	0.40	
				Jun-20	222	0.31	
				May-20	237	0.32	
				Apr-20	205	0.28	
				Min	137	0.19	
				Max	296	0.40	
				Average	219	0.30	

Parameter	Value	Unit
Average load (vs time)	0.30	MWe
Load Factor (vs capacity)	27	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	795	kWh th / h
Correction for losses and ineligible loads	846	kWh th / h
Average HHV of fuel for generation	922	kWh th / h

South West Water – 2

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00412SGEN	Hayle STW CHP - D	335	REGO	Aug-21	162	0.22	686
				Jul-21	135	0.18	
				Jun-21	132	0.18	
				May-21	135	0.18	
				Apr-21	122	0.17	
				Mar-21	115	0.15	1476
				Feb-21	107	0.16	
				Jan-21	124	0.17	
				Dec-20	119	0.16	
				Nov-20	120	0.17	
				Oct-20	135	0.18	
				Sep-20	127	0.18	
				Aug-20	131	0.18	
				Jul-20	121	0.16	
				Jun-20	119	0.17	
				May-20	119	0.16	
				Apr-20	139	0.19	
				Min	107	0.15	
				Max	162	0.22	
				Average	127	0.17	

Parameter	Value	Unit
Average load (vs time)	0.17	MWe
Load Factor (vs capacity)	16	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	462	kWh th / h
Correction for losses and ineligible loads	492	kWh th / h
Average HHV of fuel for generation	536	kWh th / h

cng services ltd

South West Water – 3

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00421SGEN	Kilmington STW CHP - D	105	REGO	Sep-20	2	0.003	12
				Aug-20	1	0.001	
				Jul-20	1	0.001	
				Jun-20	2	0.003	
				May-20	2	0.003	
				Apr-20	4	0.01	
				Min	1	0.001	
				Max	4	0.01	
				Average	2	0.003	

Parameter	Value	Unit
Average load (vs time)	0.003	MWe
Load Factor (vs capacity)	0.2	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	7	kWh th / h
Correction for losses and ineligible loads	8	kWh th / h
Average HHV of fuel for generation	8	kWh th / h

cng services ltd

South West Water – 4

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00414SGEN	Plympton STW CHP - C,D	270	REGO	Aug-21	86	0.12	492
				Jul-21	107	0.14	
				Jun-21	97	0.13	
				May-21	95	0.13	
				Apr-21	107	0.15	
				Mar-21	110	0.15	518
				Feb-21	82	0.12	
				Sep-20	52	0.07	
				Aug-20	67	0.09	
				Jul-20	103	0.14	
				Jun-20	92	0.13	
				May-20	12	0.02	
				Min	12	0.02	
				Max	110	0.15	
				Average	84	0.12	

Parameter	Value	Unit
Average load (vs time)	0.12	MWe
Load Factor (vs capacity)	10	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	307	kWh th / h
Correction for losses and ineligible loads	327	kWh th / h
Average HHV of fuel for generation	356	kWh th / h

South West Water – 5

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00422SGEN	Totnes STW CHP - D	105	REGO	Aug-21	17	0.02	47
				Jul-21	23	0.03	
				Jun-21	7	0.01	
				Aug-20	15	0.02	155
				Jul-20	10	0.01	
				Jun-20	49	0.07	
				May-20	46	0.06	
				Apr-20	35	0.05	
				Min	7	0.01	
				Max	49	0.07	
				Average	25	0.03	

Parameter	Value	Unit
Average load (vs time)	0.03	MWe
Load Factor (vs capacity)	3	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	92	kWh th / h
Correction for losses and ineligible loads	97	kWh th / h
Average HHV of fuel for generation	106	kWh th / h

Wessex Water – 1

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
G00839SGEN	Avonmouth STW CHP Generation - A,C,D,E	5750	REGO	Sep-21	1034	1.44	6952	Average load (vs time)	1.17	MWe
				Aug-21	984	1.32		Load Factor (vs capacity)	53	%
				Jul-21	1632	2.19		Adjusted Efficiency	37.6	%
				Jun-21	1143	1.59		Average LHV of fuel for generation	3113	kWh th / h
				May-21	1250	1.68		Correction for losses and ineligible loads	3312	kWh th / h
				Apr-21	909	1.26		Average HHV of fuel for generation	3610	kWh th / h
				Mar-21	697	0.94	8478			
				Feb-21	457	0.68				
				Jan-21	689	0.93				
				Dec-20	963	1.29				
				Nov-20	926	1.29				
				Oct-20	967	1.30				
				Sep-20	477	0.66				
				Aug-20	653	0.88				
				Jul-20	580	0.78				
				Jun-20	720	1.00				
				May-20	663	0.89				
				Apr-20	686	0.95				
				Min	457	0.66				
				Max	1632	2.19				
				Average	857	1.17				

Wessex Water – 2

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00843SGEN	Berryhill STW - A,C	900	REGO	Sep-21	495	0.69	1517
				Aug-21	613	0.82	
				Jul-21	116	0.16	
				Jun-21	108	0.15	
				May-21	125	0.17	
				Apr-21	60	0.08	
				Mar-21	82	0.11	1448
				Feb-21	129	0.19	
				Jan-21	137	0.18	
				Dec-20	130	0.17	
				Nov-20	121	0.17	
				Oct-20	112	0.15	
				Sep-20	112	0.16	
				Aug-20	122	0.16	
				Jul-20	121	0.16	
				Jun-20	126	0.18	
				May-20	128	0.17	
				Apr-20	128	0.18	
				Min	60	0.08	
				Max	613	0.82	
				Average	165	0.23	

Parameter	Value	Unit
Average load (vs time)	0.23	MWe
Load Factor (vs capacity)	20	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	599	kWh th / h
Correction for losses and ineligible loads	637	kWh th / h
Average HHV of fuel for generation	695	kWh th / h

Wessex Water – 3

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year	Parameter	Value	Unit
G00841SGEN	Poole STW CHP Generation - A,C,D	1395	REGO	Sep-21	68	0.09	883	Average load (vs time)	0.24	MWe
				Aug-21	94	0.13		Load Factor (vs capacity)	22	%
				Jul-21	149	0.20		Adjusted Efficiency	37.6	%
				Jun-21	152	0.21		Average LHV of fuel for generation	640	kWh th / h
				May-21	209	0.28		Correction for losses and ineligible loads	681	kWh th / h
				Apr-21	211	0.29		Average HHV of fuel for generation	742	kWh th / h
				Mar-21	182	0.24	2282			
				Feb-21	167	0.25				
				Jan-21	168	0.23				
				Dec-20	211	0.28				
				Nov-20	147	0.20				
				Oct-20	219	0.29				
				Sep-20	153	0.21				
				Aug-20	219	0.29				
				Jul-20	229	0.31				
				Jun-20	201	0.28				
				May-20	164	0.22				
				Apr-20	222	0.31				
				Min	68	0.09				
				Max	229	0.31				
				Average	176	0.24				

Wessex Water – 4

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G00842SGEN	Taunton STW CHP Generation - A C D E	850	REGO	Sep-21	468	0.65	2407
				Aug-21	461	0.62	
				Jul-21	355	0.48	
				Jun-21	343	0.48	
				May-21	392	0.53	
				Apr-21	388	0.54	
				Mar-21	334	0.45	3575
				Feb-21	385	0.57	
				Jan-21	375	0.50	
				Dec-20	366	0.49	
				Nov-20	220	0.31	
				Oct-20	284	0.38	
				Sep-20	343	0.48	
				Aug-20	324	0.44	
				Jul-20	219	0.29	
				Jun-20	199	0.28	
				May-20	265	0.36	
				Apr-20	261	0.36	
				Min	199	0.28	
				Max	468	0.65	
				Average	332	0.46	

Parameter	Value	Unit
Average load (vs time)	0.46	MWe
Load Factor (vs capacity)	41	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	1211	kWh th / h
Correction for losses and ineligible loads	1288	kWh th / h
Average HHV of fuel for generation	1404	kWh th / h

Wessex Water – 5

Accreditation No.	Generating Station / Agent Group	Station TIC	Scheme	Output Period	No. of Certificates	Load (MWe)	No. of Certificates per Financial Year
G01319SGEN	Trowbridge STW New CHP	1166	REGO	Mar-21	5	0.01	92
				Feb-21	6	0.01	
				Jan-21	56	0.08	
				Dec-20	2	0.00	
				Nov-20	5	0.01	
				Oct-20	12	0.02	
				Sep-20	4	0.01	
				Aug-20	1	0.00	
				May-20	1	0.00	
				Min	1	0.001	
				Max	56	0.08	
				Average	10	0.01	

Parameter	Value	Unit
Average load (vs time)	0.01	MWe
Load Factor (vs capacity)	1	%
Adjusted Efficiency	37.6	%
Average LHV of fuel for generation	37	kWh th / h
Correction for losses and ineligible loads	39	kWh th / h
Average HHV of fuel for generation	43	kWh th / h