United Utilities

Bioresource, Energy & Carbon Services

Energy Review: Leigh WwTW

May 2022

United Utilities

Water for the North West

Revision	Date	Description	Author	Reviewer	Approver
Rev 1	**16th May 2022**	**First Draft**	**J Harper**		
Rev 2	**23rd May 2022**	**Second Draft**	**J Harper**		
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Energy Management

Overview

Our energy management strategy aims to achieve an appropriate balance between managing energy consumption, use of renewables and self-generation and being smart about how we operate our assets to get best value while maintaining security of supply. This is achieved through our energy management programme which brings together management processes, asset optimisation and data analytics.

This programme of work allows Energy Services and our operational teams the opportunity to work closely in order to raise engagement around energy awareness, reduce overall consumption and concentrate on new innovative ways in order to run our treatment process in most efficient way. After a series of workshops with key stakeholders on a participating site and consideration of the various opportunities which have been identified to be more efficient, Energy Services are able to develop an Energy Management Plan that underpins the sites action plan, sites specific STOD Rates and a day by day working strategy for site to follow. Keeping up with this allows us as a business to maintain a work ethic geared around being more efficient, flexible and smarter in the way we use our energy.

Energy Standard

To support our energy management plan we have developed an Energy Standard which is scoring matrix where Energy Services can highlight areas for a participating site to focus on as part of the Energy Management Programme. This scoring matrix is scored by key stakeholders with the guidance of the programme lead and energy engineers. Through providing the key stakeholders the ability to peer assess their own performance gives a strong indication of areas they need to focus on, and the opportunity to discuss ways in which better practice can be achieved. The scoring is based on the following criteria:

- Leadership
- Monitoring
- TRIAD Management
- Flexible Operation
- Maintaining the Energy Management Plan
- Unit Cost to Treat
- Unit cost of energy
- Engagement and awareness
- Training completion

Each unit is scored 1 to 5 and an action plan is devised on the back of this piece of work for site to improve. Dependant on the sites score they receive a certificate of completion varying from Platinum, Gold, Silver and Bronze. Energy Services run through this yearly with each site with the aim to achieve a higher score next time highlighting improvement on performance.

Energy Awareness & Training

We have developed a set of bespoke energy training packages which are delivered through our e-learning platform, the aim of these courses is to build awareness and engagement around energy use and to improve understanding across the business to enable us to use less, use smarter and generate more.

There are three energy training courses available, the first is centred on our energy use, cost and goals, and to encourage everyone in UU to help reduce our energy use and costs. There are also two further training courses which are specific to our water and wastewater operational teams which provide a walkthrough of our main treatment processes and the associated activities we can implement to improve the efficiency of our operations.

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Energy Savings Opportunity Scheme (ESOS)

In 2019 we submitted our declaration to the EA for ESOS (Energy Saving Opportunities scheme) which confirms our approach for energy management across the business. In our overall ESOS compliance report, Bioresource, as a large consumer of energy was identified as one of the key areas of specific energy consumption (SEC). The phase 2 ESOS report and analysis provided an overarching energy review for Bioresources and surfaced energy opportunities which are being investigated over AMP7. These overarching opportunities include for example focusing on biogas production & utilisation, optimisation of CHP engine performance, energy efficiencies in sludge handling & dewatering, a reduction in the use of fossil fuels for heating to support digestion and utilisation of waste heat.

Analytics

The continued development of our energy analytics and reporting capability allows us to effectively monitor energy consumption and generation across the business and to identify opportunities for efficiencies to reduce consumption, avoid peak tariffs and to generate more renewable energy. Investment in powerclips will allow us to monitor individual energy consuming assets such as pumps to assess their energy efficiency and to determine the most energy efficient operation. Further sub-metering across Bioresource will enable the energy consumption to be reviewed independently of the co-located WwTW and to identify further energy saving opportunities. The roll-out of the additional sub-metering is on-going.

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Leigh WwTW

Site Overview

Leigh Wastewater Treatment Works (WwTW) is located in the metropolitan borough of Wigan, Greater Manchester and serves a population equivalent of 78,628[1]. The treatment works consists of primary treatment (settlement) following which flows are pumped through to biological filters then on to hummus tanks with BAFF as a tertiary treatment.

The treatment works is co-located with a Bioresource sludge treatment facility which treats the indigenous sludge from the co-located works along with imported liquid sludge from a number of wastewater treatment works in the surrounding region. The Bioresource facility treats sewage sludge via advanced anaerobic digestion by utilising a CAMBI thermal hydrolysis pre-treatment process, the digestate is then dewatered via centrifuge and the resulting enhanced treated sludge cake is used as a fertiliser in agriculture. Liquors from the thickening and dewatering of sludge is treated using an AMTREAT process to remove ammonia from the liquors before being returned to the head of the works.

Biogas is produced during the digestion of the sewage sludge which is consumed in two 527kW Jenbacher combined heat & power (CHP) engines to produce electricity to power the WwTW and Bioresources facility. Steam is generated for the thermal hydrolysis process via a single steam boiler with a fuel oil & biogas burner and heat recovery from the CHP engines.

Leigh WwTW further benefits from an on-site 1,246 kW photovoltaic array which provides an annual generation of circa 850MWh per annum.

Overall Energy Balance

The biogas fuelled CHP engines at Leigh WwTW provide circa 56% of the sites total electricity consumption, an additional 11% is provided by the on-site PV array and the remaining demand is imported from grid. Heat is recovered from the CHP engines from both the water circuit and exhaust which meets 28% of the heat demand for the thermal hydrolysis plant, the remaining steam demand is produced from natural gas firing with the option to utilise biogas. A summary of the overall energy balance is displayed in figure 1.

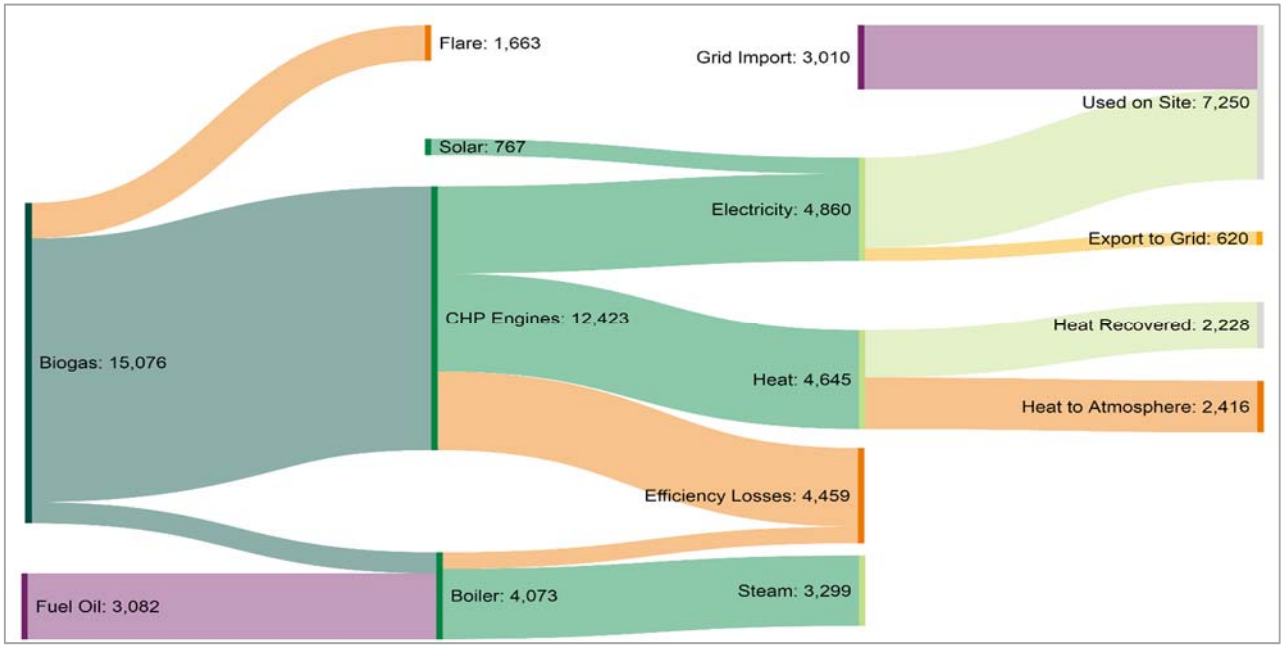

Figure 1 - Leigh WwTW - FY22 Energy Balance

[1] Wastewater Explanatory Factors (WEF) 2022

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Biogas Production & Use

Biogas is produced by the Bioresource facility through the anaerobic digestion of sewage sludge, the site benefits from a thermal hydrolysis pre-treatment prior to anaerobic digestion which increases biogas production in addition to producing an enhanced digestate. Biogas production at Leigh WwTW was an average of 376 Nm3 per tonne of dry solids (tDS) processed in FY21-FY22, this is against an asset standard of 428 Nm3 per tonne of dry solids which suggests there is some opportunity to improve biogas production and subsequent energy generation.

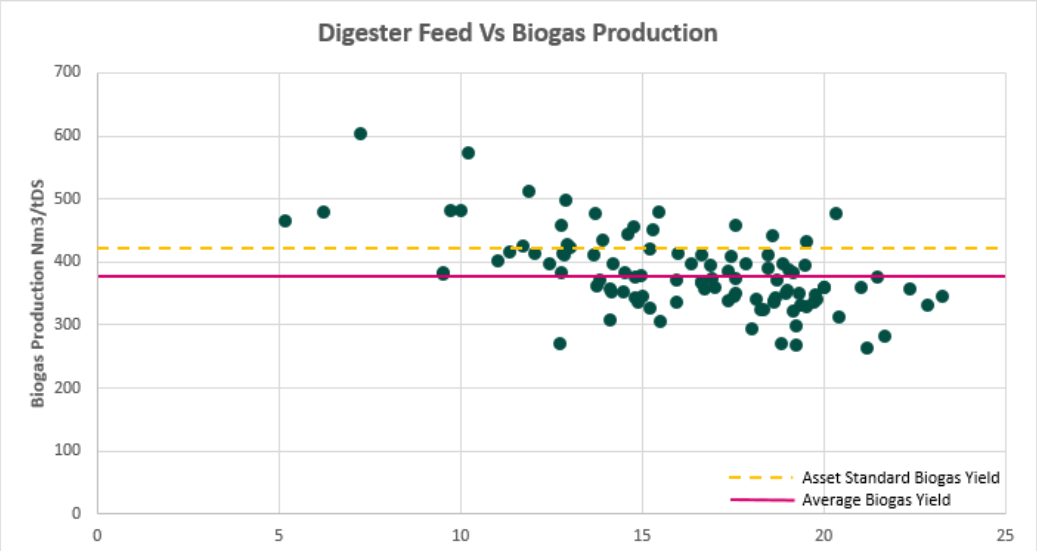

Figure 2 – Leigh WwTW Biogas Yield

The CHP engines on site are the primary consumers of the biogas produced from the digestion process, however the steam boiler has the capability to operate on biogas. Increased use of biogas supply to the boiler has been seen from January-March 2022 as we try to reduce our consumption of fossil fuels in-line with our carbon reduction ambitions.

The average operating load of the engines is circa 50% across FY21 & FY22 which suggests that an increase in biogas production either through increased biogas yield or increased sludge throughput could be accommodated and would further offset consumption of electricity from grid and fossil fuel use in the steam boiler.

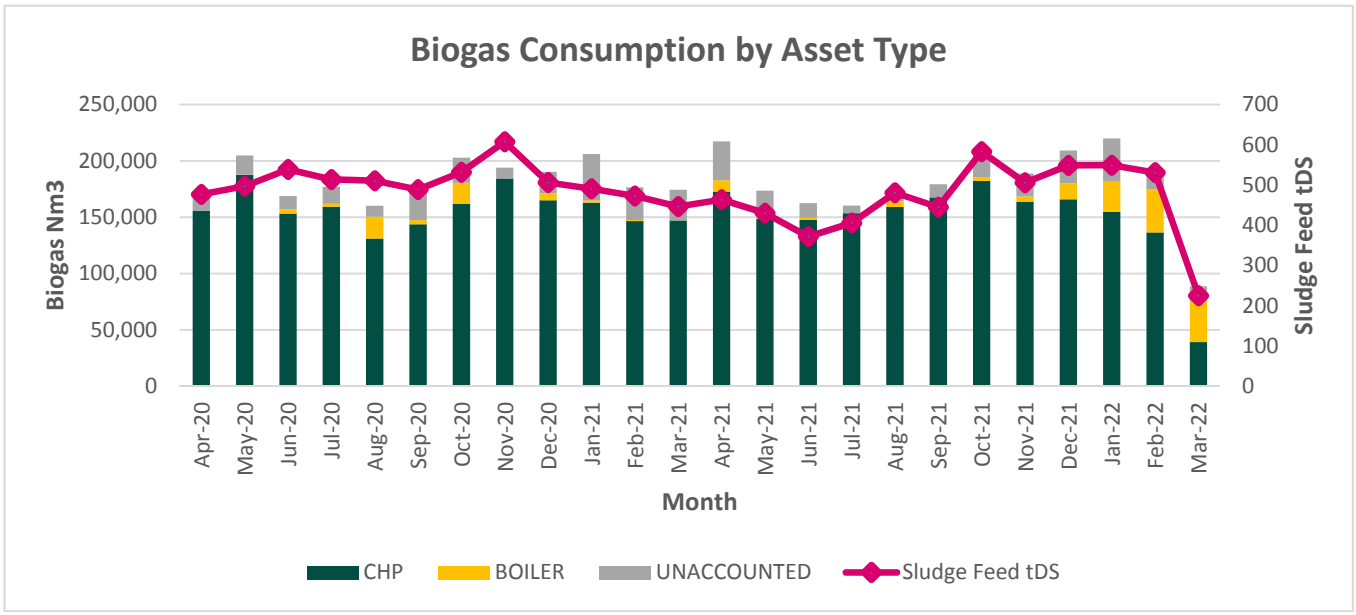

Figure 3- Leigh WwTW Biogas Consumption

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Electricity Consumption

The average electricity demand across FY21 & FY22 at Leigh WwTW was 851kW, met through a combination of generation from our biogas fuelled CHP engines, on-site PV generation and import from grid (on a renewable tariff). Generation is consumed on site to offset electricity which would otherwise be purchased from grid with any surplus energy being exported to grid. An overview of monthly energy generation and consumption is shown in Figure 4.

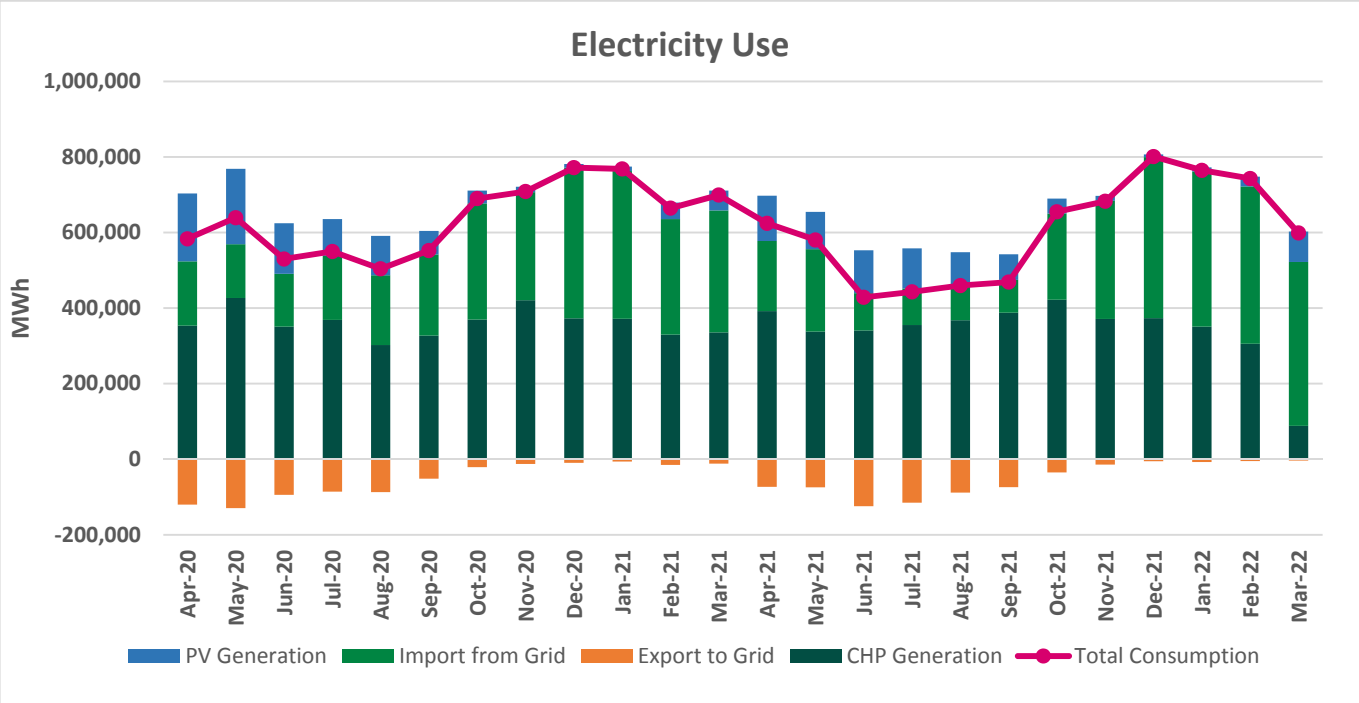

Figure 4 - Leigh WwTW Electricity Consumption

The energy demand of Leigh WwTW is seasonal coinciding with periods of increased flow to the wastewater treatment works driven primarily by weather. This is reflected in figure 5 where increased consumption can be seen in the autumn and winter periods compared to the spring and summer months.

Seasonal time of day (STOD) control is in operation on a number of energy consuming assets and on the CHP engines, providing flexibility in the use and generation of electricity on the site and therefore allowing the avoidance of periods of high energy costs, particularly TRIAD periods. This is demonstrated in the autumn and winter periods between 4pm-7pm in figure 5.

The specific energy consumption of Leigh WwTW, quantified as the relative measure of electricity consumption per unit of flow to treatment is 1.079 MWh/ML which is within the expected range for this size and type of treatment works. The relationship between flow to treatment and electricity use is shown in figure 6 & 7.

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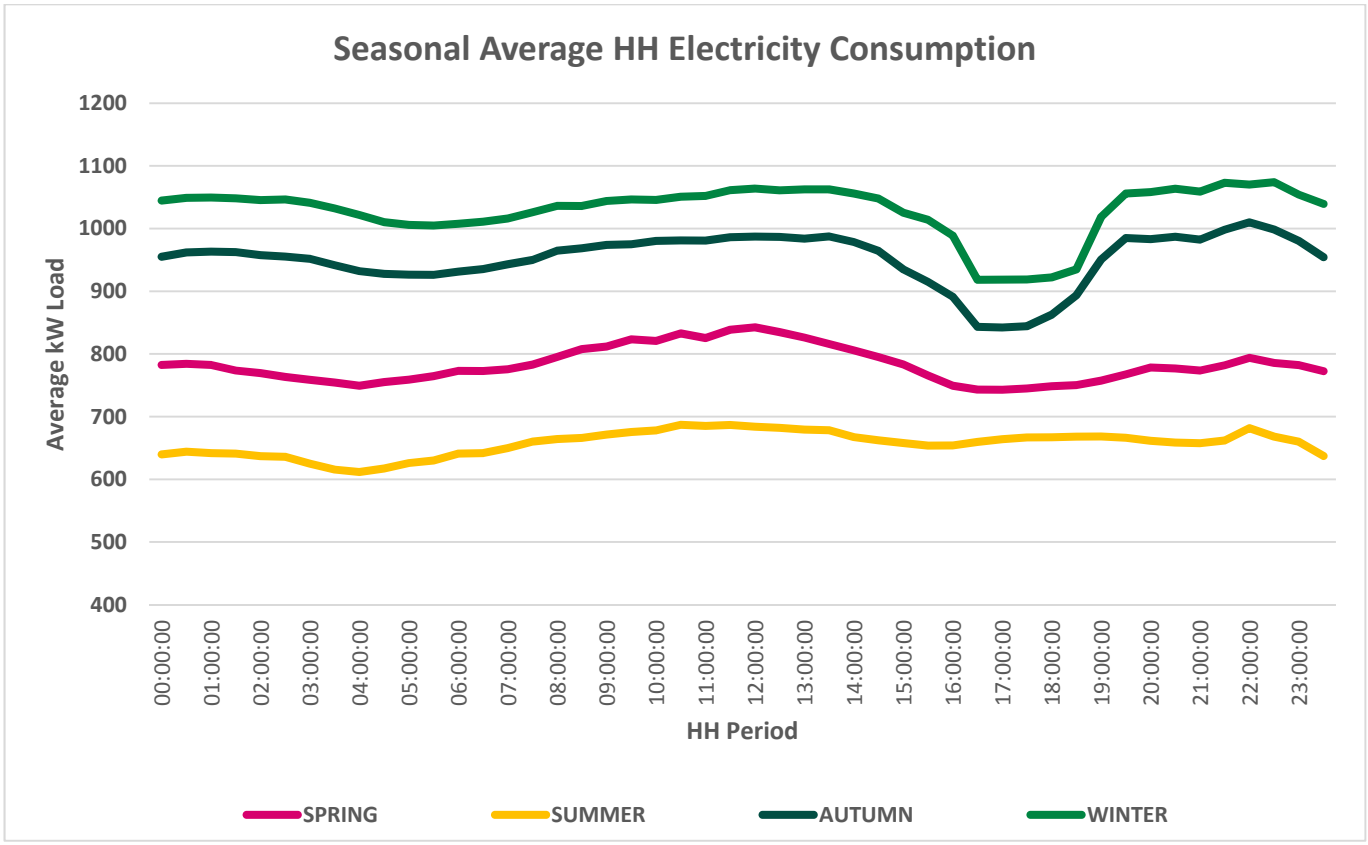

Figure 5 - Leigh WwTW Average HH Electricity Consumption

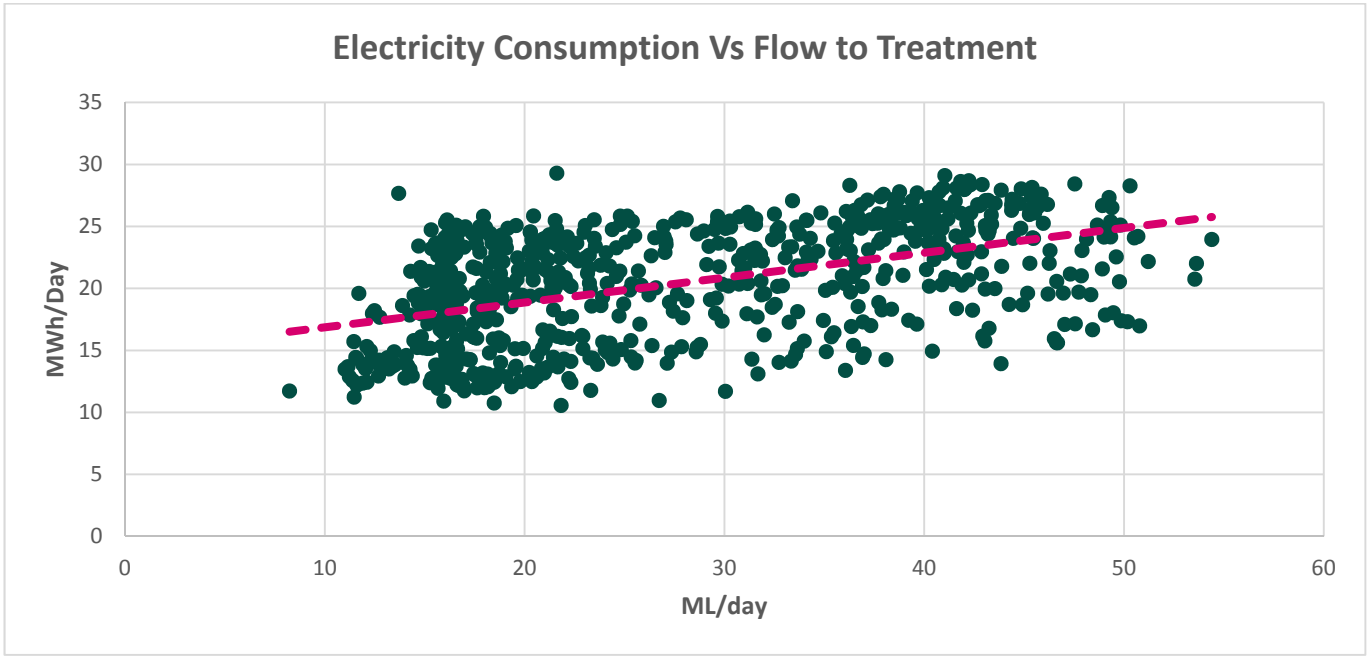

Figure 6- Leigh WwTW - Electricity Consumption vs Flow

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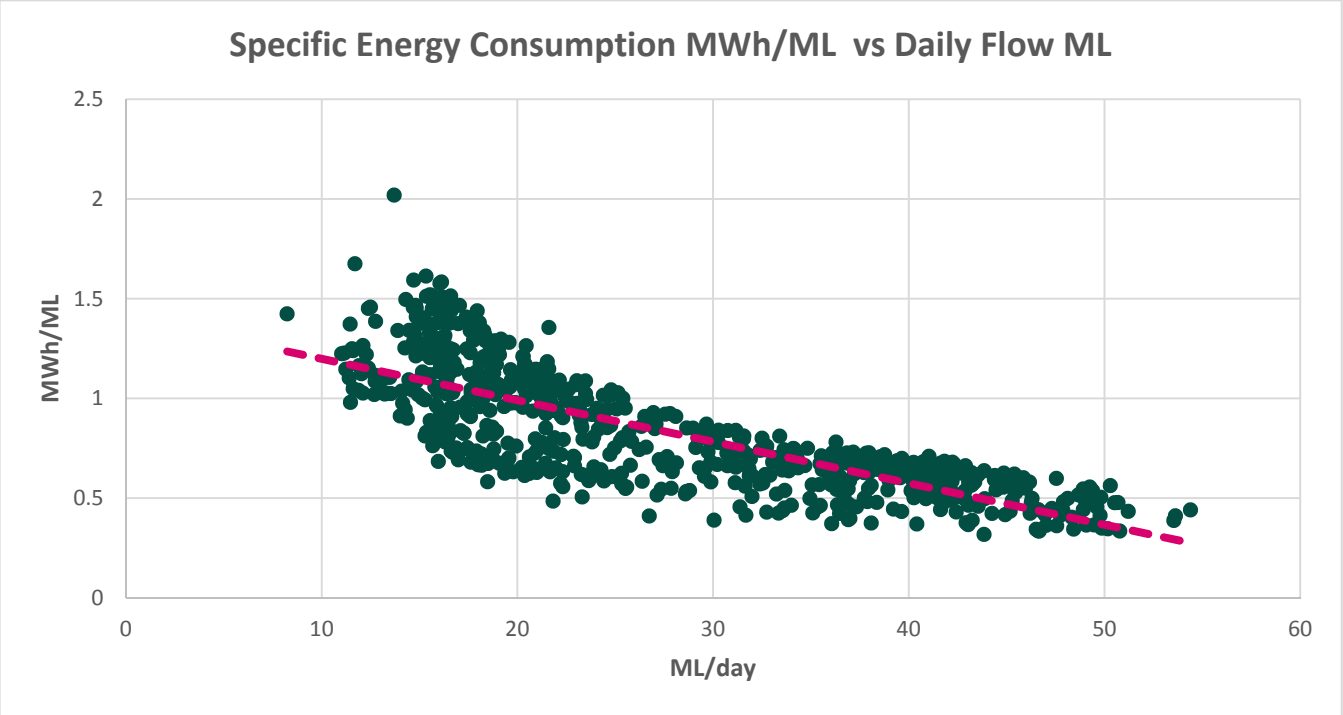

Figure 7 - Specific Electricity Consumption MWh/ML

Energy Generation

United Utilities operate and maintain a fleet of combined head and power (CHP) engines with a dedicated team responsible for the overhaul and maintenance. Proactive maintenance and monitoring of the engines along with detailed analytics ensures a high-level of engine availability and performance.

At Leigh WwTW there are two biogas-fuelled CHP engines (two x 527kW Jenbacher J312), an analysis shows the electrical efficiency[2] across FY21 & FY22 of 36.71% and 36.20% for CHP1 and CHP2 respectively, which is within the expected range when accounting for parasitic load[3].

An important aspect of our energy management philosophy is to use (and generate) energy smarter, at Leigh WwTW the CHP engines are fitted with control software to maximise generation during peak periods as demonstrated below in figure 10.

[2] Electrical efficiency is calculated at the lower heating value (LHV) of the fuel

[3] Available metering measures electrical generation after the deduction of parasitic load

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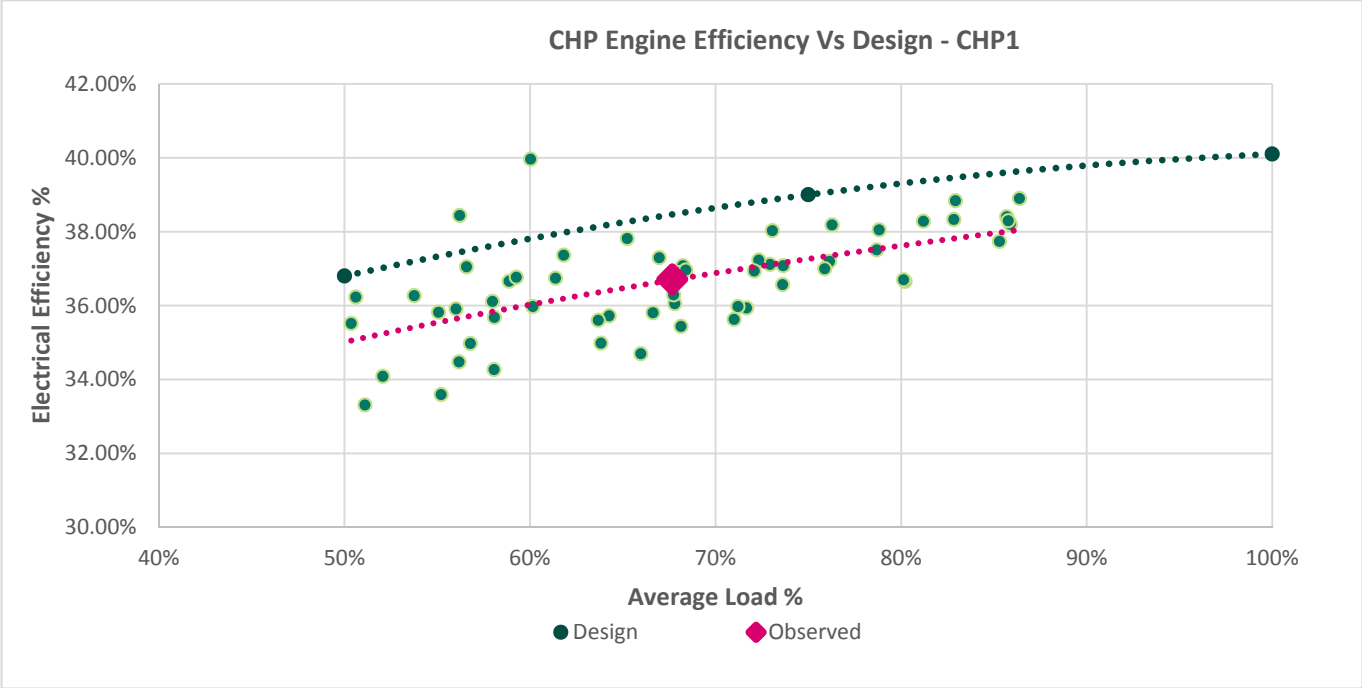

Figure 8- Leigh WwTW CHP1 Efficiency

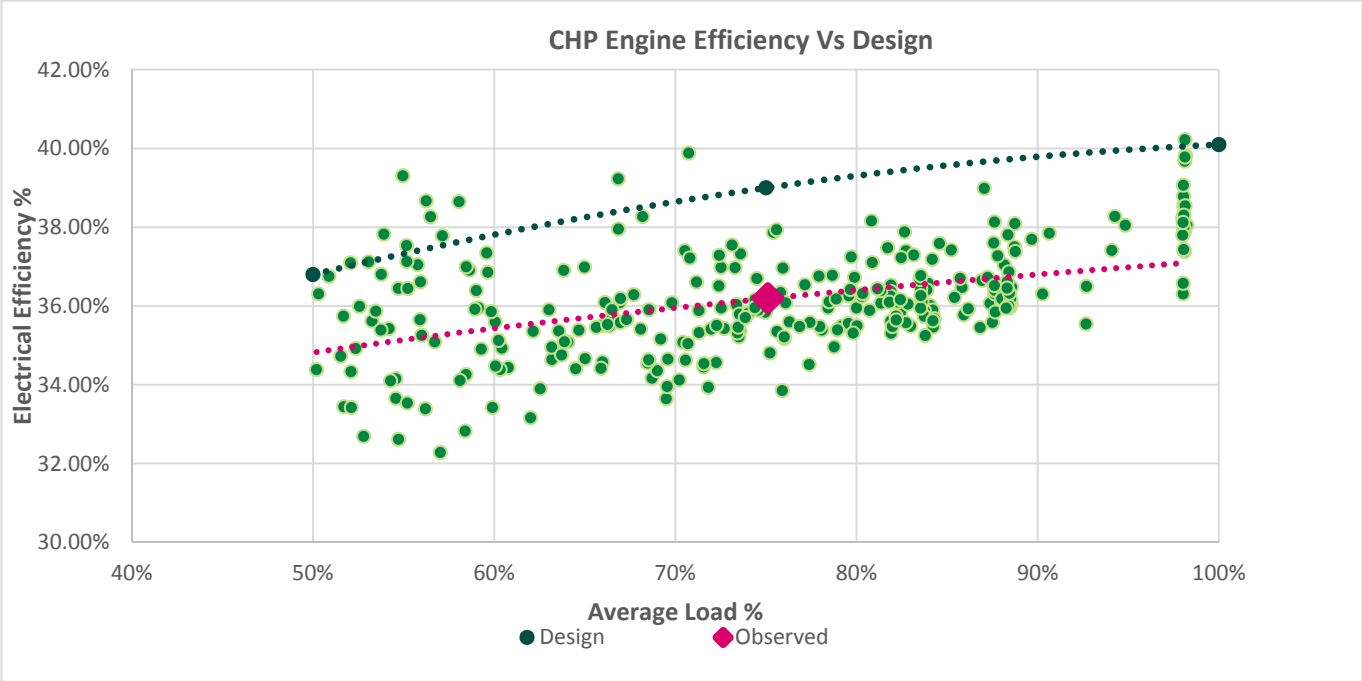

Figure 9 - Leigh WwTW CHP2 Efficiency

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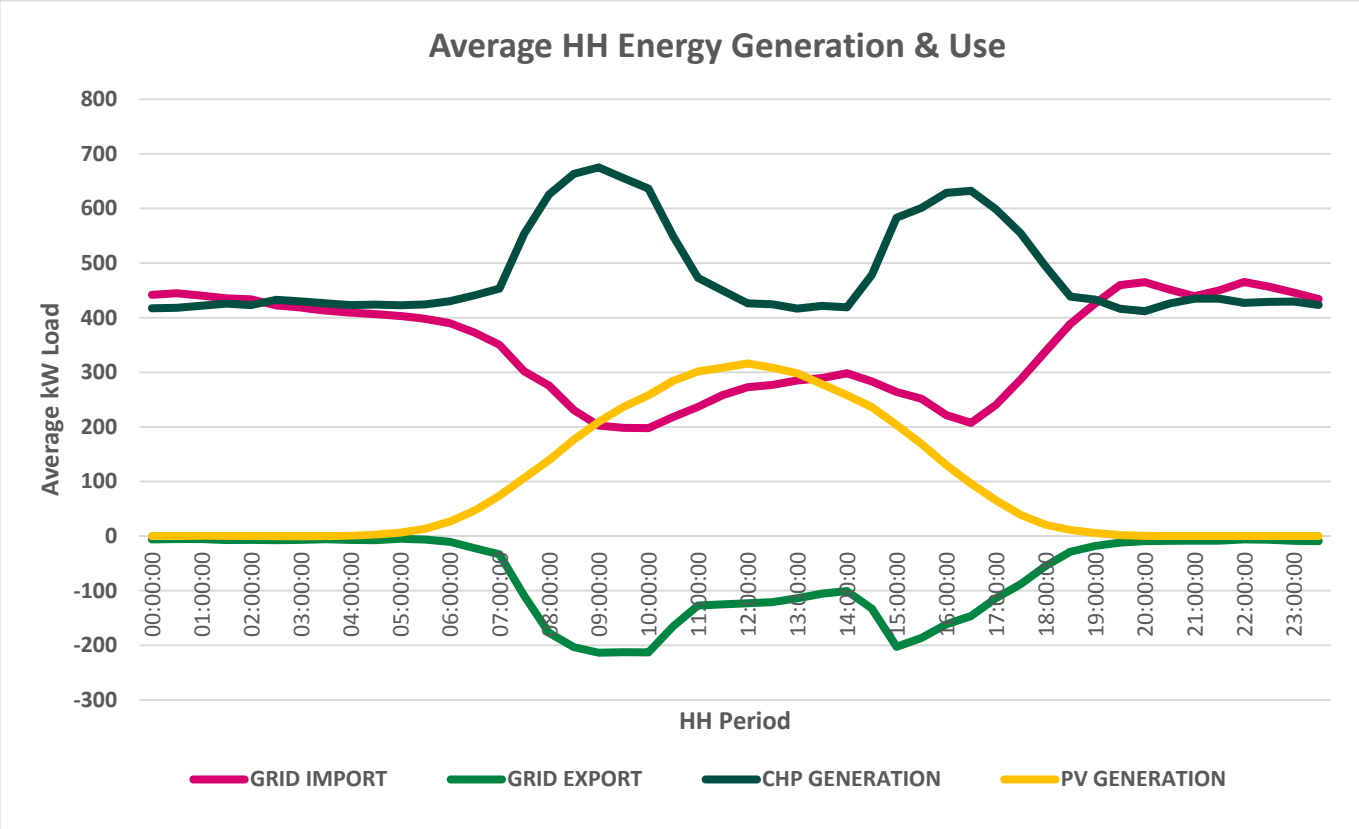

Figure 10 - Leigh WwTW - Average Electricity Generation & Use

Heat Use

Stationary fuel (gas oil) is used at Leigh WwTW as the primary fuel to the steam boilers in order to provide steam to the thermal hydrolysis pre-treatment process. There is the potential to operate the steam boilers using biogas generated from the digestion process and therefore reduce the amount of stationary fuel use. In January – March 2022 an increasing amount of biogas has been used in the steam boiler, offsetting the consumption of fuel oil as shown in figure 11[4]

The average heat demand for the thermal hydrolysis plant over FY21 & FY22 is calculated to be 1017 kWh(th) per tonne of dry solids treated which is within the design specified by CAMBI, however there is the opportunity to review the heat balance of the site to ensure maximum CHP heat recovery and minimise fuel oil use in the steam boilers.

[4] Fuel oil consumption is derived from purchasing data.

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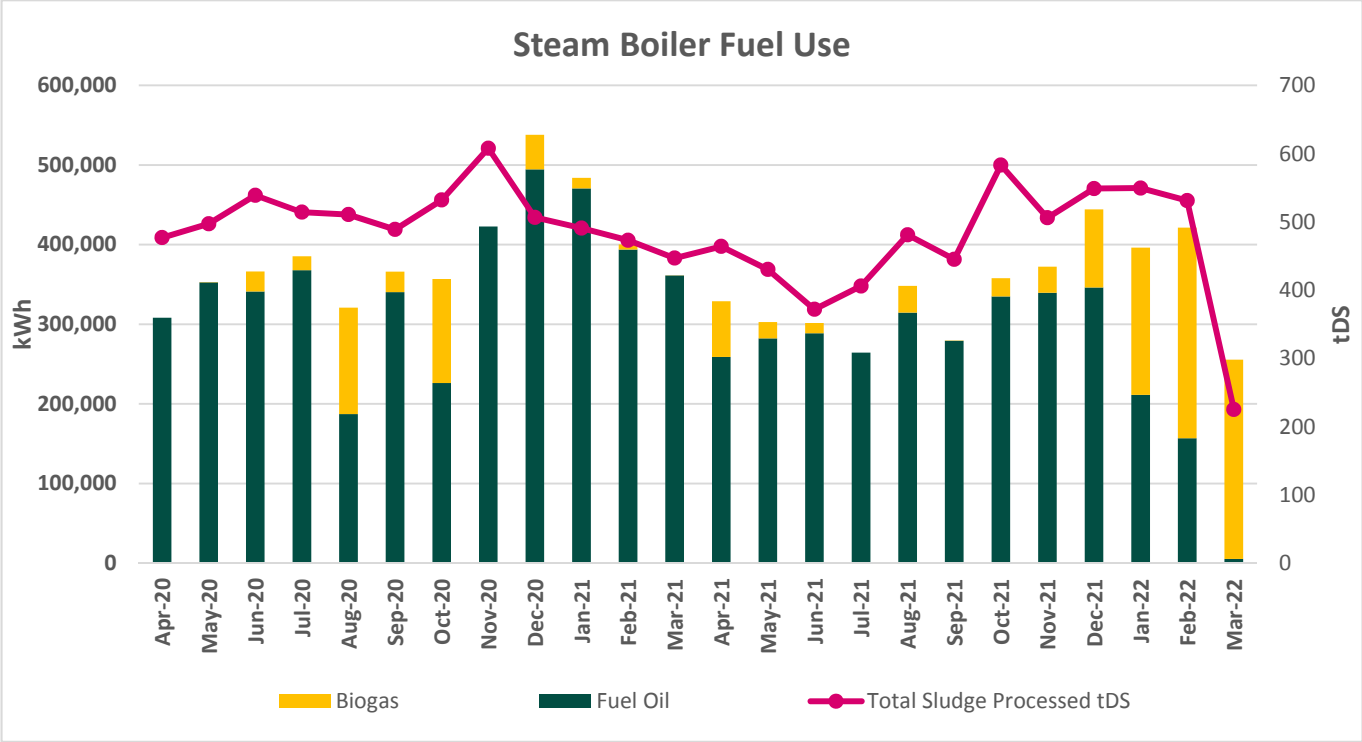

Figure 11 - Leigh WwTW - Steam Boiler Fuel Use

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Energy Management Opportunities

There are a number of activities and projects that are being delivered in AMP7 to support energy efficiency and management across the business, in particular those most relevant to Leigh WwTW are detailed below.

Metering & Analytics

Across our operational sites we are installing powerclips on our significant energy consuming assets in order to monitor and review our energy consumption, this allows us to identify individual assets which are performing poorly and to optimise operation. Further to the powerclips we are also planning to install sub-metering across the Bioresource facility which will allow us to determine the energy consumption of the Bioresource operation independently of the WwTW.

At Leigh WwTW powerclips have been deployed across the large energy consuming assets including the inlet & filter screw pumps, BAFF plant, backwash pumps and blowers to aid in our management of energy consumption on a more granular level. Additional powerclips and sub-metering on Bioresources assets are due to be installed in FY23.

Energy Workshops & Energy Standard

Leigh WwTW obtained a Silver award in our energy standard in 2020 and a number of energy saving opportunities were identified and have been actioned such as SToD control on electricity consumers CHP generation. Further opportunities to reduce energy consumption are being investigated such as SToD control on additional asssets, control development on the BAFF plant and optimisation of flows throughout the works.

Summary of Energy Management Opportunities

Opportunity	Improvement, kWh/yr	Potential Saving, £/yr	Carbon Benefit	Rationale	Time-scales	Owner
Installation of sub-metering (powerclips)	Reduce site consumption by 2-5% (based on our experience at other sites)	In the range of 150,000 – 375,000 kWh which is circa £15-38k	Reduction in the amount of energy imported from grid. UU purchases green energy and therefore action would not reduce carbon emissions (based on carbon accounting practices)	Metering will provide a greater insight to consumption at an asset and process level. Integrate analysis and review into energy management programme	6-12 months	Production Engineer
Reduce fuel oil use in boilers	TBC	TBC	Will reduce carbon emissions from fossil fuel use, using biogas will result in a carbon release but this is from a biogenic source.	Investigate options to utilise biogas in the steam boilers and reduce fuel oil use and thereby reduce fuel costs and carbon emissions.	On-going	Production Engineer
Improve Biogas Yield	Potential to increase by circa 52 Nm3 per tDS (based on asset standard)	Potential circa 288,000 Nm3 of biogas resulting in circa 1662 MWh of generation and £80k of revenue (grid import + ROC)	Will increase renewable generation of heat and power allowing off-set of fuel oil use in boilers and a reduction in grid electricity import.	Analysis shows biogas yield lower than expected. Further investigation required to determine the root cause and potential increase in production.	6-12 months	Production Engineer

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SToD Control	TBC	TBC	None, energy consumption would remain roughly the same but be consumed during non-peak times.	There are multiple assets on site which could benefit from SToD control such as AMTREAT electric boiler, centrifuge, bio-filter recirculation and de-sludging.	12-18 months	Energy Engineer
BAFF Optimisation	TBC	TBC	Will reduce the amount of electricity use.	Reinstate ammonia control on BAFF. Currently inefficient as running in fall back mode.	6-12 Months	Energy Engineer
Embed energy management philosophy with operational team.	TBC	TBC	Reduction in energy use through improved ways of working.	Engagement with operational team to encourage and maintain energy awareness and to identify further opportunities for energy reductions	On-going	Energy Engineer

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Appendix

Energy Balance Data

Leigh WwTW	2020/21		2021/22	
Flow to Treatment (Ww)		**ML**		**ML**
		10,747		8,990
Sludge Treatment	**m3**	**tDS**	**m3**	**tDS**
Cambi TH Throughput	38,567	6,083	35,896	5,542
Energy Use [a]				
Biogas Use	**Nm3**	**MWh**	**Nm3**	**MWh**
Boilers	57,202	396	142,955	991
CHP	1,899,404	13,166	1,792,153	12,422
Flare / Unaccounted	239,815	1,662	239,903	1,663
Total Biogas Produced	**2,139,218**	**15,224**	**2,032,056**	**15,076**
Electricity		**MWh**		**MWh**
CHP Electricity Generation (Biogas)		4,330		4,093
PV Generation		943		767
Renewable Electricity Export to Grid [b]		645		620
Electricity Import from Grid [c]		3,033		3,010
Total Site Consumption		**7,661**		**7,250**
Heat		**MWh**		**MWh**
Boilers Heat from Biogas [d]		321		803
Boilers Heat from Fuel Oils		3,456		2,497
CHP Heat Recovery		2,485		2,228
CHP Heat to Atmosphere [e]		2,429		2,416
Total Heat		**8,690**		**7,944**
Stationary Fuels	**Litres**	**MWh**	**Litres**	**MWh**
Fuel Oil - Boilers	397,245	4,266	287,017	3,082
Total Fuel Oil	**397,245**	**4,266**	**287,017**	**3,082**
Energy Balance		**MWh**		**MWh**
Energy Input				
Biogas		15,224		15,076
Electricity from Grid		3,033		3,010
PV Generation		943		767

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Fuel Oil	4,266	3,082
Total Energy In	**23,467**	**21,935**
Energy Output		
CHP Electricity Generation	4,330	4,093
CHP Heat	4,913	4,645
Boiler Heat	3,777	3,299
CHP Efficiency Losses	3,922	3,685
Boiler Efficiency Losses	886	774
Electricity from Grid Used on site	3,033	3,010
PV Generation	943	767
Flared/Unaccounted Biogas	1,662	1,663
Total Energy Out	**23,467**	**21,935**

(a) Energy quoted at the Gross Calorific Value (GCV)

(b) Export from PV array and Biogas Fuelled CHP

(c) Electricity purchased from grid on a renewable tariff (REGO)

(d) Assumed boiler efficiency of 81%

(e) Calculated as the difference between manufacturer design heat output and measured heat recovered

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