United Utilities

Bioresource, Energy & Carbon Services

Energy Review: Southport WwTW

May 2022

United Utilities

Water for the North West

Revision	Date	Description	Author	Reviewer	Approver
Rev 1	**27th May 2022**	**First Draft**	**J Harper**		
Rev 2	**1st June 2022**	**Second Draft**	**J Harper**		
Rev 3	**6th June 2022**	**Third 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.

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.

Southport WwTW

Site Overview

Southport Wastewater Treatment Works (WwTW) is located in the coastal town of Southport in Merseyside and serves a population equivalent of 96,398[1]. The treatment works consists of an activated sludge process (ASP) followed by final settlement where the surplus activated sludge is then thickened via a gravity belt thickener (GBT). The final effluent under-goes ultra violet (UV) disinfection prior to discharge to the outlet of the WwTW.

The treatment works is co-located with a Bioresource sludge treatment facility which treats the thickened indigenous sludge from the co-located works along with a small amount of imported liquid sludge from a number of wastewater treatment works in the surrounding region. The Bioresource facility treats sewage sludge via anaerobic digestion, the digestate is then dewatered via centrifuge and the resulting treated sludge cake is recycled to land.

Biogas is produced during the digestion of the sewage sludge which is consumed in a single 637kW Jenbacher combined heat & power (CHP) engine to produce electricity to power the WwTW and Bioresources facility. Heat recovery from the CHP engine provides the majority of the heat required to maintain digester temperature, with additional heat provided by a natural gas fired boiler with the option to utilise Biogas.

Overall Energy Balance

The biogas fuelled CHP engine at Southport WwTW provides circa 35% of the sites total electricity consumption and the remaining demand is imported from grid. Heat is recovered from the CHP engine which meets 92% of the heat demand for maintaining digester temperature, the remaining heat demand is met through natural gas firing with the option to utilise biogas. A summary of the overall energy balance is displayed in figure 1.

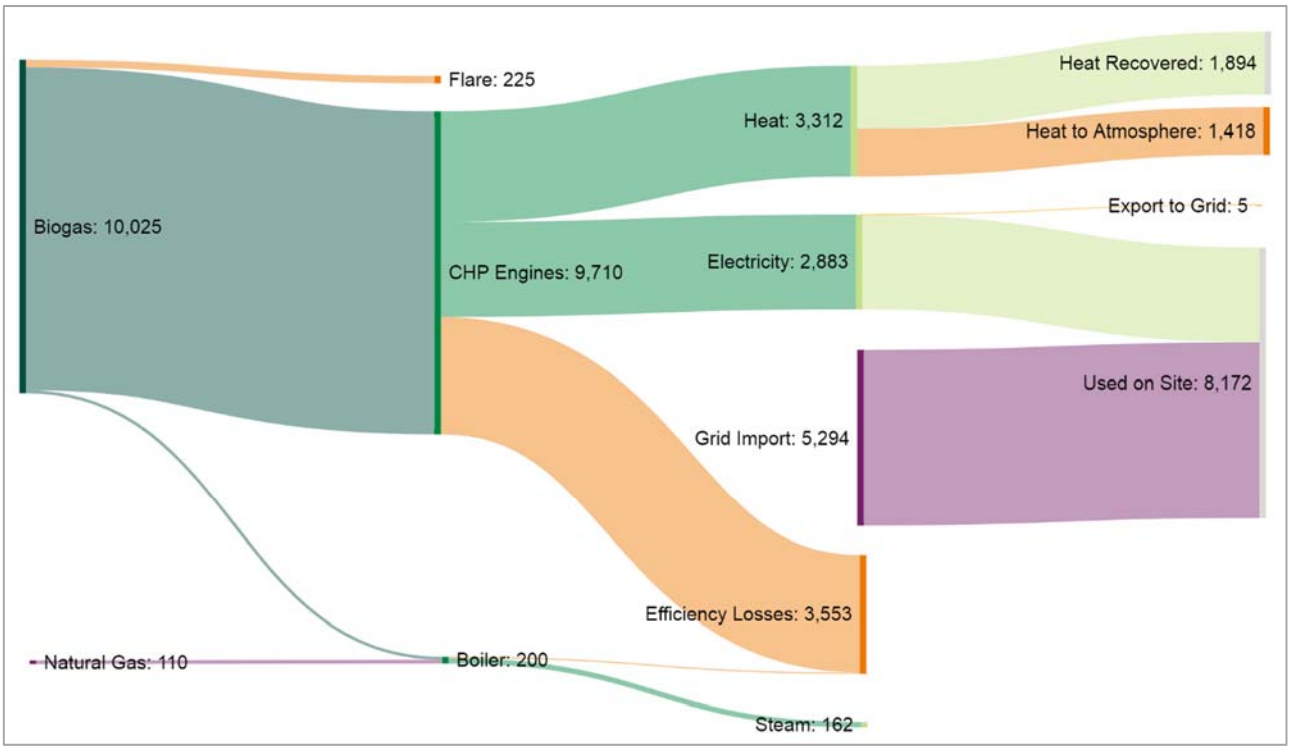

Figure 1 - Southport WwTW - FY21 Energy Balance

[1] Wastewater Explanatory Factors (WEF) 2022

Biogas Production & Use

Biogas is produced by the Bioresource facility through the anaerobic digestion of sewage sludge, biogas production at Southport WwTW was an average of 375 Nm3 per tonne of dry solids (tDS) processed in FY21-FY22, this is against an asset standard of 320 Nm3 per tonne of dry solids processed.

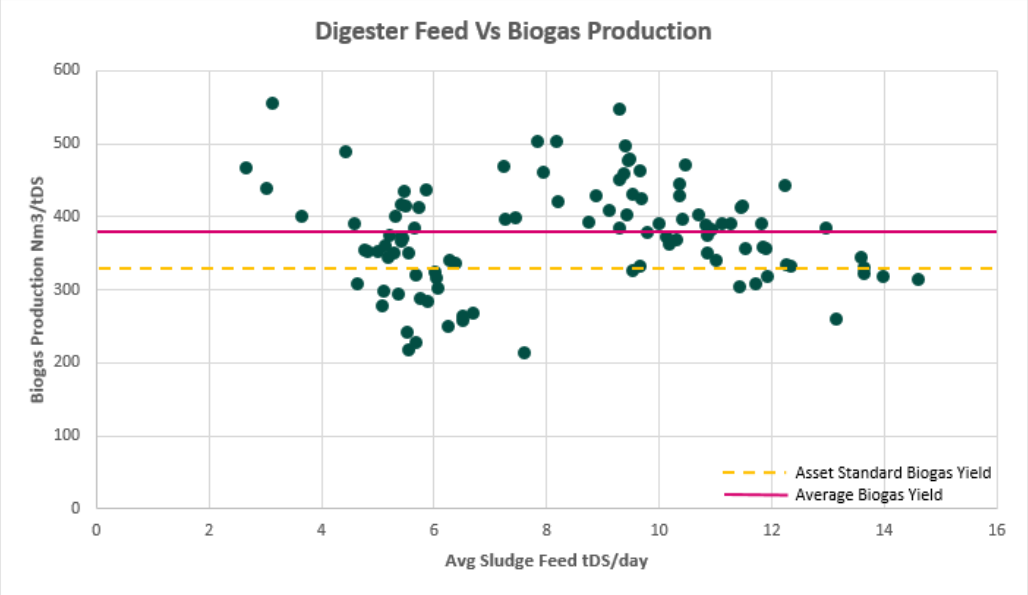

Figure 2 – Southport WwTW Biogas Yield

The CHP engine on site is the primary consumers of the biogas produced from the digestion process, the boiler for digester heating has the capability to operate on biogas however boiler use is low as the majority of the heating demand is provided from the CHP engine.

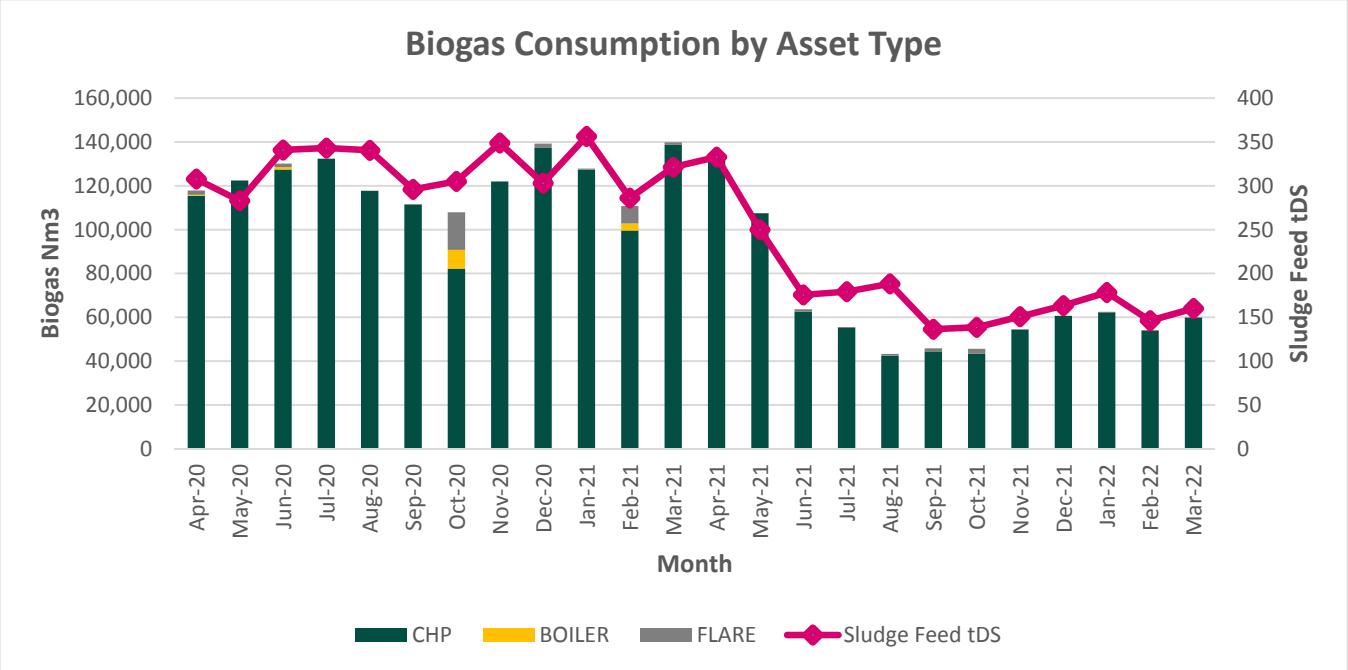

Figure 3- Southport WwTW Biogas Consumption

Electricity Consumption

The average electricity demand across FY21 & FY22 at Southport WwTW was 888kW, met through a combination of generation from our biogas fuelled CHP engines 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.

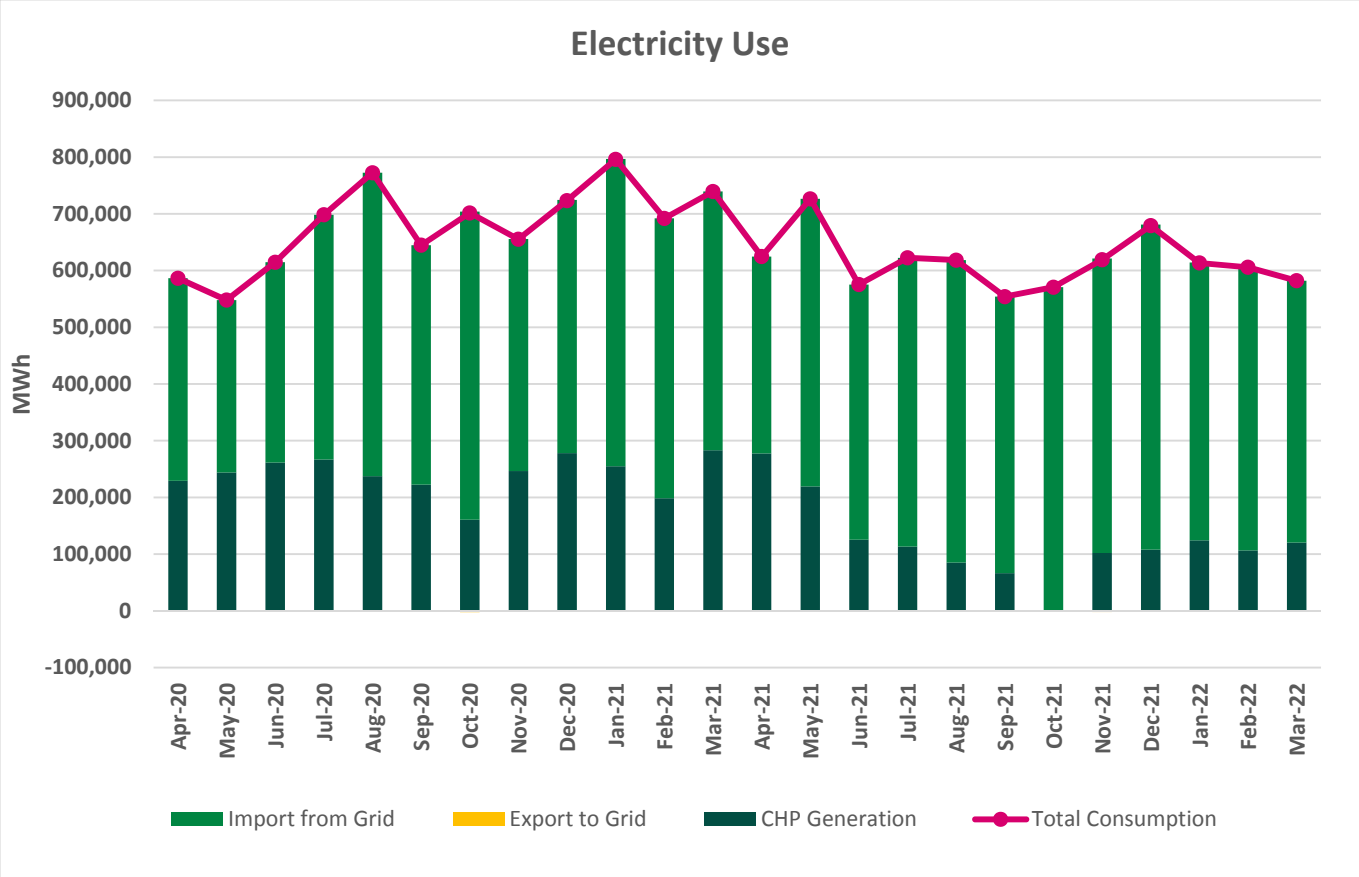

Figure 4 - Southport WwTW Electricity Consumption

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.

The specific energy consumption of Southport WwTW, quantified as the relative measure of electricity consumption per unit of flow to treatment is 0.49 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 5 & 6.

Powerclips have been installed across Southport WwTW to measure energy consumption of individual large power consuming assets such as inlet & outlet pumps, sludge pumps, UV disinfection and ASP blowers to facilitate improvements energy management by assessing asset efficiency and identifying areas for improved software control or intervention.

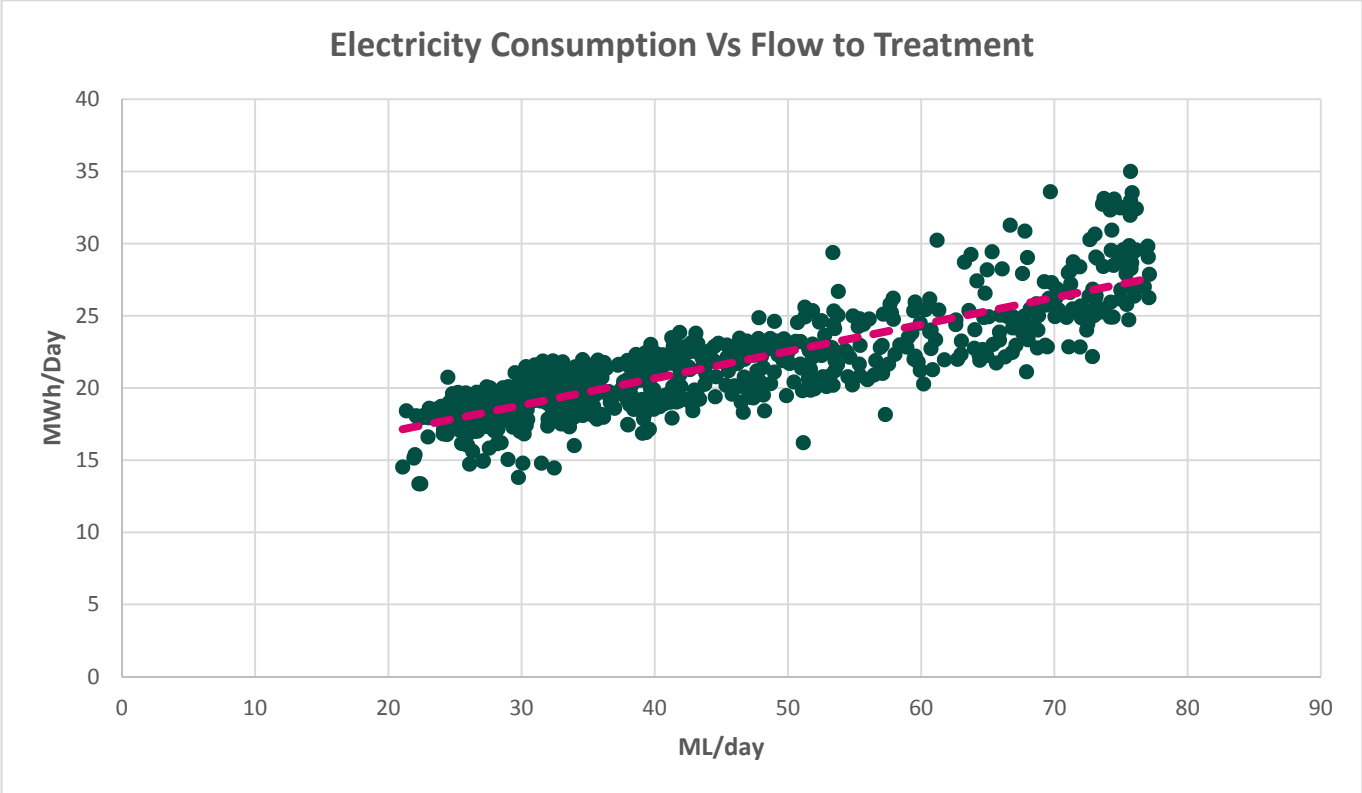

Figure 5- Southport WwTW - Electricity Consumption vs Flow

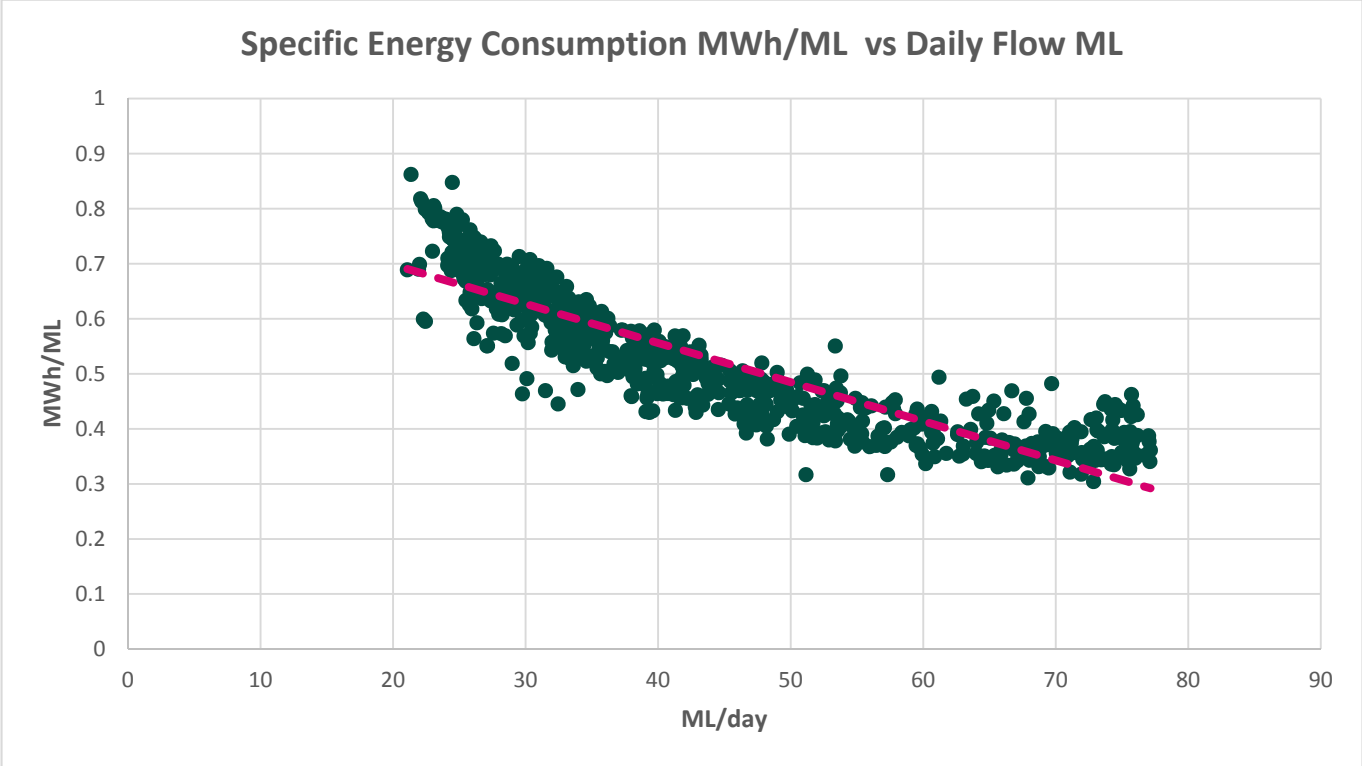

Figure 6 - Specific Electricity Consumption MWh/ML

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 Southport WwTW there is a single biogas-fuelled CHP engine 637kW Jenbacher), an analysis shows the electrical efficiency[2] across FY21 & FY22 of 33.60% which is slightly lower than the expected range when accounting for parasitic load[3], which suggests there is potential to improve electrical efficiency.

An important aspect of our energy management philosophy is to use (and generate) energy smarter, at Southport WwTW the CHP engines are fitted with control software to maximise generation during peak periods as demonstrated below in figure 8.

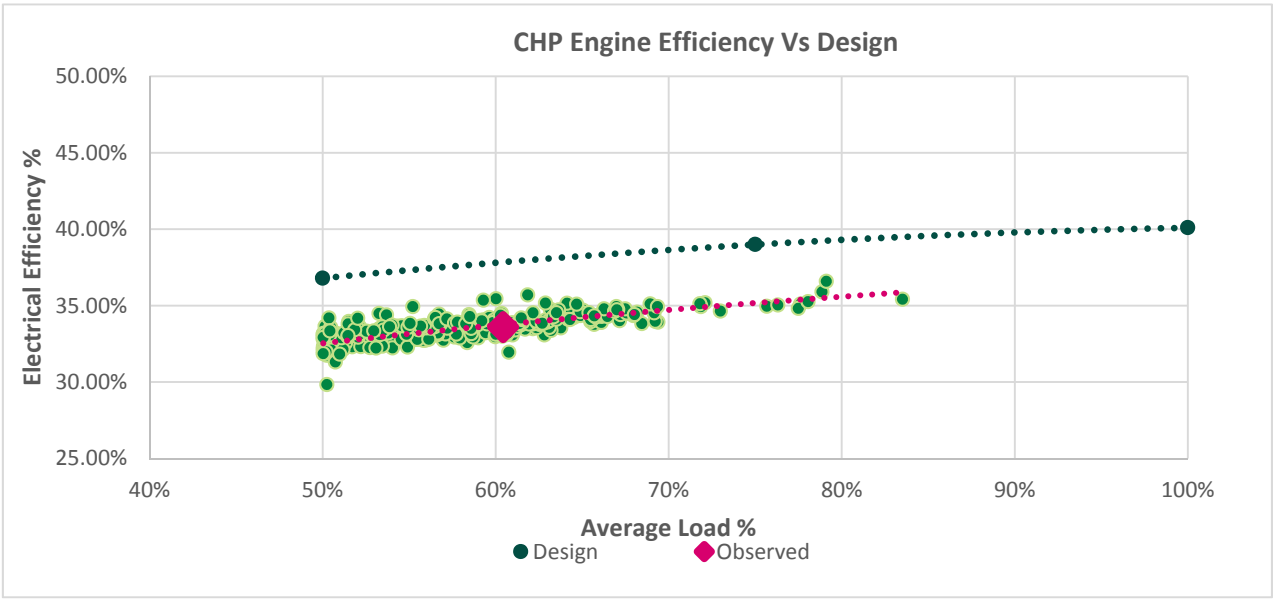

Figure 7 - Southport WwTW CHP Efficiency

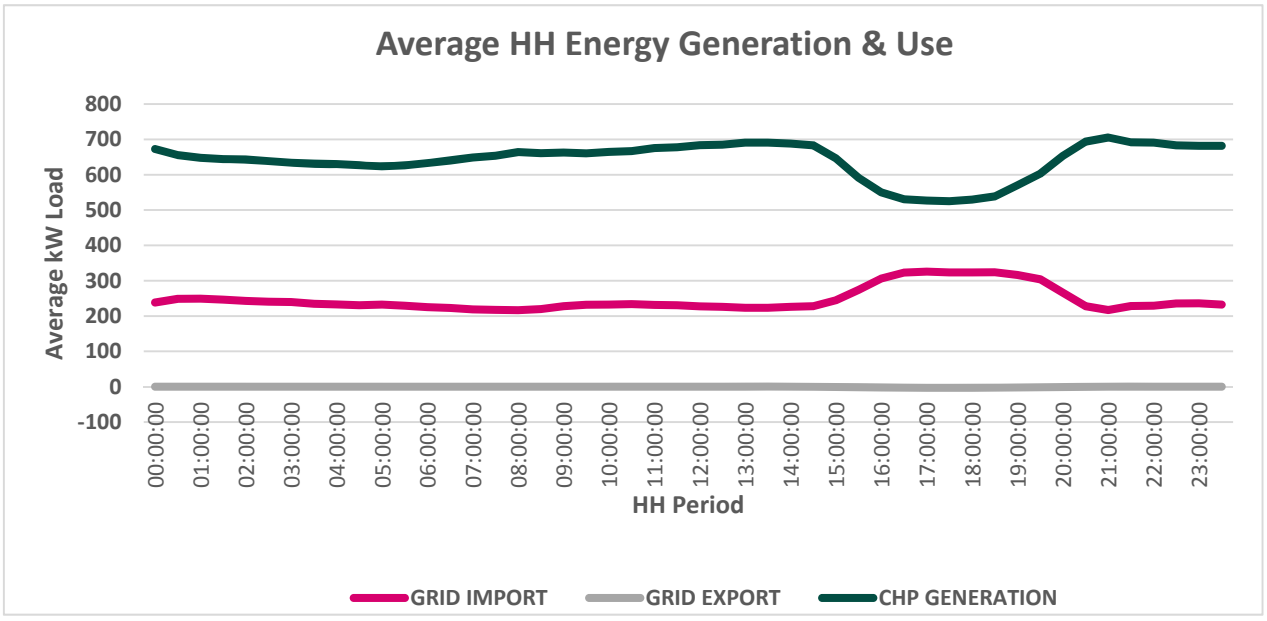

Figure 8 - Southport WwTW - Average Electricity Generation & Use

[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

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 Southport 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 Southport WwTW powerclips have been deployed across the large energy consuming assets including the inlet & outlet pumps, UV disinfection plant and ASP 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

Southport 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 and CHP generation. Further opportunities to reduce energy consumption are being investigated and are outlined in the table below.

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	On-going	Energy Engineer
ASP Blower change	TBC	TBC	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)	Currently operating on a duty/standby configuration with the less efficient blowers as standby. Will allow two high efficiency blowers to operate on duty.	On-going	Energy Engineer
CHP Electrical Efficiency Improvement	Up to 5% improvement, additional 79,000 – 144,000 kWh/yr	£7-15K/yr + ROC income	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)	CHP electrical efficiency is slightly below design standard. Potential to improve efficiency.	6-12 months	CHP & Production Engineering

Ferryside / interceptor pumps	TBC	TBC	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)	Air eliminators to be installed on one of the pumps to judge the effect on performance.	On-going	Energy Engineer
Installation of additional flow meters	TBC	TBC	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)	Additional submetering to be installed on all pumps. Combined with powerclip data this will allow assessment of pump efficiency and potential for energy savings by optimising operation.	On-going	Energy Engineer
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 RAS and Sludge pumps.	12-18 months	Energy Engineer
UV Plant optimisation	TBC	TBC	Will reduce the amount of electricity use.	Optimisation of set points can reduce electricity consumption	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

Appendix

Energy Balance Data

Southport WwTW	2020/21		2021/22	
Flow to Treatment (Ww)		**ML**		**ML**
		17,405		14,335
Sludge Treatment	**m3**	**tDS**	**m3**	**tDS**
Digester Throughput	81,900	3,832	44,214	2,199
Energy Use [a]				
Biogas Use	**Nm3**	**MWh**	**Nm3**	**MWh**
Boilers	13,304	90	19	0
CHP	1,433,925	9,710	780,639	5,286
Flare	33,217	225	7,116	48
Total Biogas Produced	**1,467,142**	**10,025**	**787,754**	**5,334**
Electricity		**MWh**		**MWh**
CHP Electricity Generation (Biogas)		2,883		1,576
Renewable Electricity Export to Grid [b]		5		5
Electricity Import from Grid [c]		5,294		5,948
Total Site Consumption		**8,172**		**7,519**
Heat		**MWh**		**MWh**
Boilers Heat from Biogas [d]		73		0
Boilers Heat from Natural Gas		89		82
CHP Heat Recovery		1,894		430
CHP Heat to Atmosphere [e]		1,418		1,380
Total Heat		**3,474**		**1,893**
Stationary Fuels		**MWh**		**MWh**
Natural Gas - Boilers [f]		110		102
Total Natural Gas		**110**		**102**

Energy Balance	MWh	MWh
Energy Input		
Biogas	10,025	5,334
Electricity from Grid	5,294	5,948
Natural Gas	110	102

Total Energy In	**15,429**	**11,384**
Energy Output		
CHP Electricity Generation	2,883	1,576
CHP Heat	3,312	1,810
Boiler Heat	162	82
CHP Efficiency Losses	3,515	1,900
Boiler Efficiency Losses	38	19
Electricity from Grid Used on site	5,294	5,948
Flared/Unaccounted Biogas	225	48
Total Energy Out	**15,429**	**11,384**

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

(b) Export from 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

(f) Derived from billed values