Ellesmere Port & Oldham CHP

combined heat and power (CHP) installations and environmental permitting regulations (EPR) improvements

by Greg Parkinson B Eng MSt (Cantab) IEng MICE MAPM & Will Taylor BSc CEng FIET

United Utilities (UU) has a renewable energy generation target of 125GWhr to be achieved in the period 2010 to 2015. Delivery of the CHP replacement projects at Ellesmere Port and Oldham WwTWs, where the old CHP engines suffered from excessive downtime and were less efficient than modern CHP engines, will assist UU in moving towards this target. New replacement engines were needed to ensure that biogas produced at these sites is fully utilised to generate electricity, which will reduce the electricity imported at each site. Biogas was also frequently wasted through flaring. Hence, an opportunity was identified for UU to provide increased CHP capacity, which, when coupled with more efficient engines provides significant operational and environmental benefits.

CHP Installation at Ellesmere Port WwTW - Courtesy of United Utilities

Project Scope

As part of the project strategy, the Environmental Permitting Regulations (EPR) improvement works, funded by OFWAT, were combined with the CHP project works, which proved to be the most efficient way of delivering the two projects.

CHP main objectives: The main objective was to replace the old CHP engines maximise the use of biogas for power generation and heat recovery for the TAD/MAD process and alleviate flaring on the sites.

EPR improvements (formerly PPC*): The improvements included:

- Provision of new flares compliant with EA requirements based on the landfill directive LFTGN05.
- Biogas clean-up (siloxane removal).
- Drainage works to seal the CHP drainage system within the PPC boundary to minimise the risk of pollution to groundwater.

Air dispersion modelling

The two WwTW sites have an Environmental Permit. For the new works a variation was applied for and given. Air dispersion modelling was carried out to assess the effects of the installation of two new larger CHPs and their emissions from their exhausts in relation to the environment. CHP stack emissions were based upon the landfill directive LFTGN08.

Siloxane removal/dehumidification

Siloxanes are a family of man-made organic compounds that contain alternate silicon, oxygen and methyl groups in either a cyclic or linear arrangement, usually with two organic (methyl) groups attached to each silicon atom.

** The Pollution Prevention and Control (PPC) regulations have subsequently been revoked and their requirements included in new legislation, EPR, The Environmental Permitting (England and Wales) Regulations.*

Oldham WwTW CHP at dawn
Courtesy of United Utilities

As a consequence of this widespread use siloxanes are found in wastewater which eventually find their way into the wastewater treatment plant as part of the liquid influent and then into the biogas during the digester process. When this gas is combusted in a gaseous fuelled engine the high temperatures and pressures cause the siloxane molecule to split, the carbon and hydrogen organic group is then free to burn off leaving behind primarily silicon dioxide which can deposit itself in the combustion chamber/ exhaust stages of the CHP engines.

Siloxane removal (carbon filters) minimises the risk of the biogas that is feeding the engines, deviating over engine manufacturer limits. It also benefits the exhaust emissions and improves engine downtime, optimising maintenance by extending the period of time between services, increased spark plug life and fewer oil changes. Dehumidification was also provided upstream of the carbon filters to meet the engine specification requirements.

Technical operating agreements

UUW had to submit applications for, and obtain, a Technical Operating Agreement (TOA) from the Electricity District Network Operator (DNO) to allow the engines to generate in parallel on their network. Protection studies were therefore required in order to provide this detail and confirm that upstream and downstream protection would operate in advance of their kit in the event of a fault condition.

Renewable Obligations Certificates (ROC) income: In order to claim Renewables Obligation Certificate (ROC) income from the new engines, the sites need to meet OFGEM requirements. An ROC is issued to an accredited generator for eligible renewable electricity generated within the United Kingdom and supplied to customers within the United Kingdom by a licensed electricity supplier. One ROC is issued for each megawatt hour (MWhr) of eligible renewable output generated.

Optimum CHP selection criteria: Optimum CHP selection depends upon the sludge throughput and hence biogas production. In this case 2 x 637kWe CHP units were selected as optimum for each site.

Common new scoping to both sites:

- Variable control on the existing boiler controls to reduce the quantity of biogas consumed by the boilers.
- Replacement of the existing CHP units with larger containerised ones, utilising all the current biogas production, and producing sufficient recoverable heat to maintain TAD and MAD temperatures throughout the year.
- Replacement of the existing flare stacks with ones capable of burning all the biogas produced by the sludge digestion process.
- Biogas pipework complete with valves, switches, meters and condensate management, including dehumidifier.
- CHP hot water circuit and transfer pumps, primary distribution pumps and heat transfer/exchange interfaces.
- Modifications to the existing hot water to sludge heat exchangers and supply and install new sludge pumps between each digester and hot water sludge heat exchanger.
- Communication systems for on site and off site reporting and control.
- High voltage/low voltage power supply and switchgear systems, including step up transformers for connection to the local power supply company network.

Ellesmere Port WwTW

Ellesmere Port WwTW sludge treatment centre treats indigenous co-settled sludge, imported thickened sludge from Birkenhead WwTW and sludge imports from small satellite works. The sludge treatment train comprises:

- Pre-thickener storage.
- Sludge screening.
- Sludge thickening;.
- Thickened sludge storage.
- Enhanced digestion using thermophilic aerobic digestion (TAD) and mesophilic anaerobic digestion (MAD).
- Post digestion storage.
- Dewatering of digested sludge.

The current sludge volumetric throughput is 425m^3/d.

Pre-upgrade CHP Installation: Biogas produced by the MADs was utilised by the 3 (No.) existing boilers to heat the TAD/MAD process and 3 (No.) *circa* 20 year old, 85kWe, CHP engines to generate electrical power.

The existing CHPs have operated beyond their asset life and required much higher maintenance. They do not export power to the grid nor do they provide thermal energy to the TAD heat exchanger matrix; thus all heat produced by the CHPs is dumped.

Boiler controls were limited to on/off, hence the boilers provided the maximum heat output whether required or not. Each of the 3 (No.) boilers is rated at 500kWt and each consumes approximately 90Nm^3/hr each.

G59 and synchronisation verification and testing: In order to parallel connect to a supply network, the equipment has to meet a 'G59 standard' to ensure safety when embedding in generation. The site required an upgraded incoming switchboard, and substation building, to ensure the increased export powers could be accommodated and separate synchronisation testing was carried out to prove when connected no disturbances to other consumers was experienced.

Oldham WwTW: Pre and post upgrade CHP Installation

Oldham WwTW Sludge Treatment Centre treats both indigenous and imported raw sludge from a number of WwTWs in the North Manchester area. The sludge treatment process comprises:

- Interceptor sludge holding tank.
- 3 (No.) sludge tanks.
- 1 (No.) thickened/tankered sludge holding tank.
- 4 (No.) mesophillic anaerobic digesters (MADs).
- 1 (No.) secondary sludge holding tank.

Digested sludge from Oldham is then pumped from the secondary sludge holding tank down the Mersey Valley Sludge Pipeline (MVSP) to Shell Green for further treatment. Biogas produced by the MADs was utilised by the 4 (No.) existing boilers and 2 (No.) 315kWe CHP engines. The boilers and CHPs were used to heat the MAD process. The CHPs were used to generate electrical power and provide heat to the process. The engines were past their asset life and in a similar situation to those at Ellesmere Port. Provision of the new engines resulted in an installed capacity of 2x637kWe.

Conclusion

The environmental benefit in not flaring off excess gas but instead using it to generate CHP is significant. Although the completed installations look relatively straightforward it should not be underestimated as to the amount of design activity required upfront to ensure all necessary regulatory compliances are met, together with the significant interfacing required between this kit and the existing infrastructure both on the wastewater plant itself and external power supply systems and processes.

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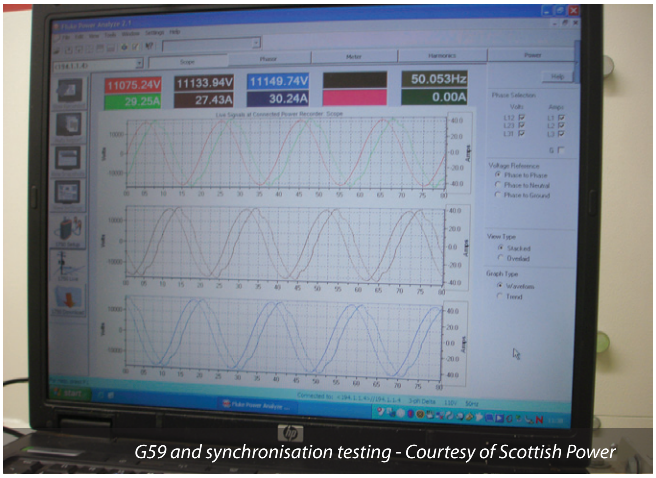

G59 and synchronisation testing - Courtesy of Scottish Power

Existing CHP engines at Ellesmere Port which are now replaced by new units - Courtesy of United Utilities

Existing and replacement flare stacks at Oldham WwTW Courtesy of United Utilities