DIGESTER METHANE EMISSIONS FLYING UNDER THE LIDAR

Pieter de Jong [1,*], Gavin Lindsay [2], Peter Wardrop [1], Dilini Seneviratne [1], Ellen Tao [1], Sebastian Hoerning [3]

1. Melbourne Water, Docklands, Victoria 3008 Australia (* Corresponding author: pieter.dejong@melbournewater.com.au)
2. QLM Technology, Arnos Vale, Bristol, United Kingdom
3. The University of Queensland, Brisbane, Queensland Australia.

Introduction

The recovery of biogas from anaerobic digesters at sewage treatment plants is common practice. However, the amount of methane lost to the atmosphere from digesters, especially those with floating roofs, is an unknown. Melbourne Water trialled a direct emission measurement technology, known as quantum gas LiDAR, aimed at improving greenhouse gas emission quantification at the Eastern Treatment Plant. The LiDAR sensor combines Tunable Diode Laser Absorption Spectroscopy with Differential Absorption Lidar and Time Correlated Single Photon Counting to measure methane fluxes up to a 200m radius. The quantum gas LiDAR was tested in the field at often overlooked fugitive emission sources such as digesters. The objective of the trial was to verify that the technology could provide measurement-based emissions quantification that in future could be used for improved estimation of emissions reporting, as well as to identify points of emissions to aid in potential emissions abatement and improved resource recovery.

Methodology

A quantum gas LiDAR supplied by QLM Technology was trialled at 2 different locations on a 10m mast for a period of 6 weeks at the Eastern Treatment Plant (see figure 1). At the first location the LiDAR was able to monitor emissions from the digesters, waste gas burners, and dehumidifier plant. From the second location emissions from the odour control facility, power station and primary sedimentation tanks were monitored. The LiDAR sensor combines Tunable Diode Laser Absorption Spectroscopy, Differential Absorption Lidar and Time Correlated Single Photon Counting together with an anemometer to measure methane fluxes up to a 200m radius. The LiDAR laser source emits a pulse of light which interacts with the pollutant gas and results in release of photons which can be detected allowing determination of both concentration and distance. As well as providing a real-time image of the methane plume, the LiDAR counts the number of molecules passing through its field of view. Using a mass balance approach, the gas plume density image is integrated and multiplied by the wind vector to calculate a flow rate across the image. For more details on the LiDAR and flux calculation, please refer to QLM white paper and case studies available at https://qlmtec.com/case_studies/

Results/ Outcomes

The quantum gas LiDAR measurement technique was able to continuously monitor, detect and quantify methane emissions at emission sources (including multiple sources in proximity to each other) common to sewage treatment plants globally, including anaerobic digesters, waste gas burners, and odour control facility. Quantifying these fugitive emissions is an important step to rectify leaks, identifying emission abatement projects and if necessary, building a business case for a lower emission alternative.

Preliminary data from the short monitoring period indicated that the average emissions measured from the floating roof seals of the digesters (see figure 2) equate to approximately 3-5% of digester methane production depending on the source of the wind data used for the calculation. However, the emissions showed variations over time (refer to figure 3). These variations are primarily likely to be related to site operation processes, and secondarily due to changes in atmospheric pressure and temperature.

Some LiDAR measurements were taken during planned digester venting operations, giving an opportunity to verify measurements against expected venting rates. The LiDAR-calculated methane fluxes compared favourably with Eastern Treatment Plant operations estimated venting volumes (see figure 4). On average the LiDAR-calculated methane flux was 127-180kg/h compared with expected methane venting of approximately 116-176kg/h.

The average emissions measured from the flares (see figure 5) was estimated to be 0.3-1.0% of the total flared methane depending on the source of the wind data used for the flux calculation. Zero emissions were detected from the dehumidifier plant, the power plant exhaust and primary sedimentation tanks. This verified that there were no unexpected emissions sources/ leaks at the Eastern Treatment Plant.

Conclusion & Recommendations

The LiDAR gas imager successfully monitored and quantified methane emissions from the digesters on a continuous basis. Emissions from the digester had never previously been measured, so the technology trial filled a knowledge gap in Melbourne Water's GHG monitoring program. Preliminary results indicated that a significant quantity of methane (3-5% of production) leaks from the digesters, which is both a loss of energy and an additional source of under reported GHG emissions. There were also some small methane emissions from the waste gas burners and the odour control facility which were expected. Therefore, while the LiDAR is useful for Leak Detection and Repair it could be particularly useful at quantifying methane emissions from facilities where emissions reporting is difficult or not sufficiently covered by emissions factors.

In order to refine these initial results a longer deployment up to 12 months using a higher mast (15-18m) is recommended. In highly built-up areas, placement of the anemometer closer to the height of the LiDAR would be recommended in order to minimize erroneous wind data impacting flux calculations. It is also recommended that the LiDAR is focussed on one digester roof seal for a sufficient period of time in order to capture emissions variations during a full cycle of the digester operations.

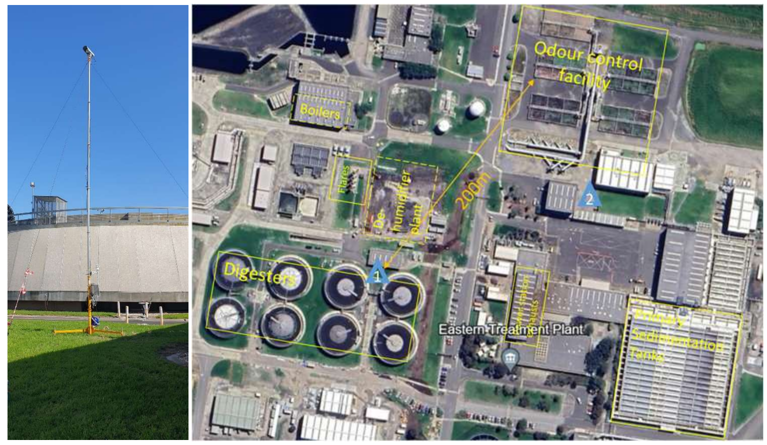

Figure 1: Quantum gas LiDAR deployment (LHS), & map showing trial locations (Δ) at the Eastern Treatment Plant (RHS)

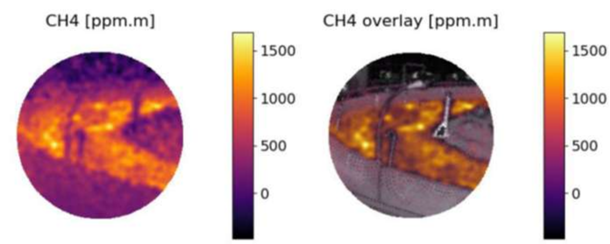

Figure 2: Emissions from floating roof seal on digester E1 of 3.4kg/h

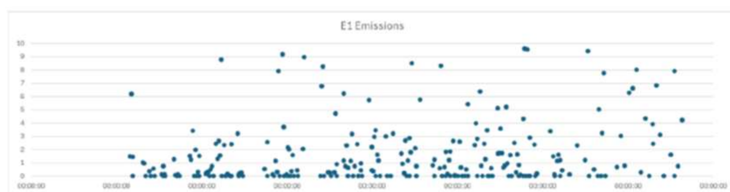

Figure 3: Time series of methane emissions (kg/hr) from floating roof seal (partial circumference) on digester E1.

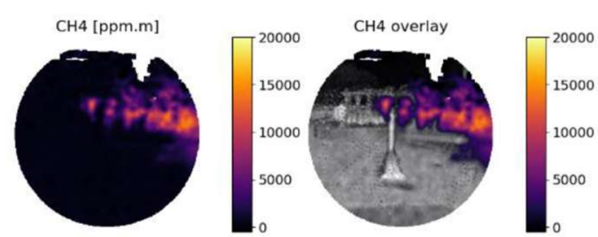

Figure 4: Venting from pressure relief valve on digester E1

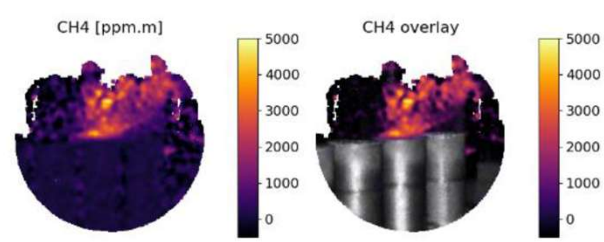

Figure 5: Peak one-off emission from flares of 10.2 kg/hr.