Treatment and Utilisation of Low Calorific Landfill Gas

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1. Introduction

Landfill gas in high and medium concentrations, is utilised for heat and/or power in furnaces, or gas-motor systems that substantially reduces the greenhouse gas (GHG) emissions and utilises the energy in the methane. Smaller sources may only be flared off to reduce GHG and odour emissions. As the landfill gas generation declines on an inactive landfill, the methane concentration will become lower than what is possible to ignite in conventional combustion systems. Co-combustion with a support fuel is possible but will reduce or offset the net greenhouse gas reduction potential.

The generation of landfill gas (LFG) will continue to decline for decades and in this timespan, an option for continued landfill gas emission control is the flameless thermal regenerative oxidation technology (FRTO), which combines energy efficiency with low emissions.

2. Demonstration Case

At the abandoned landfill in Visby, Gotland the concentration of methane had dropped to the level where the existing hot water boiler for district heating no longer operated economically.

The "Region Gotland" together with "GEAB" contacted "MEGTEC Systems AB" who together applied the flameless regenerative thermal oxidation technology (FRTO) for energy efficient lean LFG emission control. When treated in the FRTO, the LFG is typically diluted to a methane concentration between 0.6 and 1% (vol.) and the methane can be oxidised without additional heat support down to 0.15%. The excess heat generated above this concentration limit is recovered in an integrated embedded heat exchanger with over 80% efficiency and used for generating hot water for the Visby district heating grid.

The equipment was installed and commissioned during the summer 2018 and have successfully been operated according to planes since the optimi-sations and evaluations period during the early fall.

Normal operation case:

Landfill gas: 90-100m^3/h with 28-30% methane.

Hot water raise 70-90°C: 170 – 200kW

3. Optional treatment

The installed dilution may be used for reducing fugitive emissions. While the focus for combustion system has been optimised to maintain the gas concentration for operation, now the focus can be to maximise gas collection. GHG and odour reduction level will be maintained, the oxidation efficiency exceeds 99.7% for methane, VOC and odorous species.

4. Environmental effect

The electricity consumption for the system operation is typically 15 kW per ton reduced CO_2 equivalent. The impact of the electricity based GHG emissions are small,

even for coal-based power this will only represent 1.2 to 1.5% of the GHG reduction and will be on the 0.1% level based on the Nordic energy mix. (coal-based power at 0.8 to 1kg CO_2/kWh and Nordic energy mix at 0.06 kg CO_2/kW). Based on the captured landfill gas treated by the FRTO, the GHG net reduction including oxidation losses and local energy consumers will be 98 to 99.5%.

The FRTO operation range in methane mass flow is typically 1:10 or more. The gas generation is typically cut to half every 6 to 8 years giving a practical operation phase of > 20 years.

The decline in landfill gas generation will with time increase the cost per reduced CO_2 equivalent. If the investment cost is absorbed by the first ten years of operation an initial 300 kW value landfill gas emission will reduce GHG with about 30,000 tons the first 10 years. Year 10 to 20 with approx. 11,000 ton CO_2 eq. Then there's as well a potential upside of recovering heat with >60% the first 10 years (potential of net 10,000 MWh) and about 40% of the year 10 to 20 oxidation heat (potential of net 2,500 MWh). The heat recovery alone the first 10 years at 30 Euro/MWh, represents a similar value as the FRTO investment.

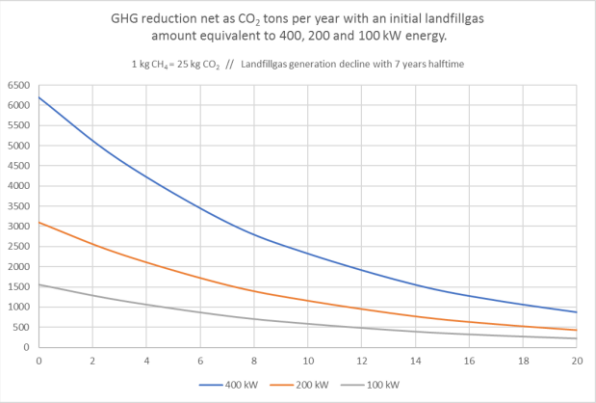

Figure 1. GHG reduction as CO_2 tons per year with an initial landfill gas amount equivalent to 400, 200 and 100 kW energy.

5. The Flameless Regenerative Thermal Oxidation technology (FRTO)

The FRTO technology in the VOCSIDIZER is well proven at more the 500 industrial VOC and HC applications.

The flameless system produces minimal amounts of thermal NOx from the air nitrogen, less than a single ppm. Other nitrogen containing volatiles in the gas, or fuel-nitrogen, as amines and ammonia will only give about 30% NOx conversion thanks to non-catalytic reduction within the ceramic media.

From sustainability perspective, the materials used in the equipment are inert and non-hazardous. After technical/ commercial limit, the steel, ceramic media/insulation and electronic compo-nents should be easily recyclable. No catalyst, precious metals or additives are used in the oxidation process, only the landfill gas heat release with the ambient air oxygen drives the process.

Figure 2. The fully containerized FRTO unit for low calorific LFG, commissioned August 2018 in Visby, Sweden.