Quantifying and Demonstrating Scrubbing H_2S from Biogas Produced by Farm-Based Anaerobic Digestion Systems

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Problem and Justification

A main operational challenge to on-farm anaerobic digestion systems (ADS) has been operational interruption of biogas-fueled engine-generator sets (EGS) due to damage from hydrogen sulfide (H_2S) in biogas, resulting in high maintenance costs and/or lost revenues. The uncertainties associated with EGS operation and biogas scrubber ability to reduce H_2S affects profitability, EGS effective lifetime, electricity production, and overall interest by farms in ADS.

With the increasing use of ADS and the large capital investment required for ADS, more guidance and evaluation information is needed for adopters. To address these knowledge deficiencies, a three-year Sustainable Agriculture Research and Education (SARE) project (2015 to 2018) has been undertaken to evaluate the efficacy of H_2S scrubbing systems on five existing farms in the Northeast, along with financial analyses of each ADS operation.

Project Goals

Specifically the SARE project will:

1) Evaluate multiple strategically-selected biogas scrubbers operating on five NE farms to document: a) effect of H_2S on EGS operation, b) determine the extent of differences in on-farm sulfur concentration, c) economic cost/benefit of scrubber operation, and d) practical aspects of daily operation and maintenance of ADS and biogas scrubbers
2) Create a Farmer's Guide to Dairy-Derived Biogas: Production, Scrubbing and Utilization
3) Host five field days in the NE
4) Develop and deliver extension/outreach materials

Project Approach

- To examine differing processes for the removal of H_2S, five farms throughout the NE were chosen: Two farms in NY and one in PA, that utilize Biological Trickling Filters
- One farm in PA that uses in-vessel air injection
- One farm in MD that uses an iron sponge system

To evaluate the effectiveness and performance of the biogas scrubbers, two Siemens Ultramat 23 Biogas Analyzers that measure CO_2, CH_4, O_2 and H_2S both before and after treatment are being used over the course of the project. The monitoring setups have been moved between farms, with system monitoring covering representative periods of seasonal operation.

In addition to collecting scrubber performance data, additional data such as capital costs, labor and operation and maintenance costs are being collected.

Preliminary Findings

System performance monitoring of the two NYS farms has finished, however the collection of operations and maintenance expenses and utility usage data is ongoing. Over the course of the 8 months the units were at each NY farm, Untreated and Treated gas samples were sampled and recorded every 15 minutes. Currently the two Siemens units are deployed on the two farms in PA.

The two NYS systems use biological trickling filters from two different companies.

NYS Farm 1:

Farm Size:	4,200 milk cows
Generation Capacity:	1 MW
H_2S Scrubber- system capital cost:	$342,000
H_2S Scrubber - annual labor cost:	$6,240/yr.
H_2S Scrubber - annual cleanout labor:	$4,920/yr.
H_2S Scrubber - annual nutrient purchases:	$3,300/yr.
H_2S Scrubber - annual trickle media replacement :	$4,195/yr.
Average Untreated H_2S Concentration:	2,640 ppm
Average Treated H_2S Concentration:	150 ppm
Capacity Factor:	0.93

NYS Farm 2:

Farm Size:	1,500 milk cows
Generation Capacity:	502 kW
H_2S Scrubber- system capital cost::	$185,000
H_2S Scrubber - annual labor cost:	$3,120/yr.
H_2S Scrubber - annual cleanout labor:	$1,220/yr.
H_2S Scrubber - annual nutrient purchases:	$8,000/yr.
H_2S Scrubber - annual trickle media replacement:	$2,150/yr.
Average Untreated H_2S Concentration:	2,353 ppm
Average Treated H_2S Concentration:	448 ppm
Capacity Factor:	0.68

Key Learned Points:

Biological treatment systems require regular (daily) check-ups and extensive cleanouts roughly twice per year.

Problems with the digester that affect biogas flow, will negatively affect the performance of the biological trickling filters. The best removal efficiency is achieved with best overall ADS system operation.

H_2S is a difficult gas to continuously monitor, and monitoring equipment requires frequent (monthly) calibrations with yearly sensor replacement.

H_2S scrubbing can easily double the interval between required oil changes for the EGS, as well as prolonging the life of engine heads and valves.