GREENHOUSE GAS FROM DAIRY MANURE MANAGEMENT AT THE FARMSTEAD

Part 10: GHG REDUCTION FROM AN ANAEROBIC DIGESTION SYSTEM

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An anaerobic digestion system (ADS) is typically designed to actively produce and capture methane (CH_4) in biogas that fuels an engine gen-set to generate renewable electricity. An ADS both reduces CH_4 production from manure storage by combusting the CH_4 to reduce its global warming potential (GWP) and producing renewable energy displacing fossil fuel.
The stored effluent may continue to emit approximately 20% more CH_4 since the temperature and bacterial populations are initially the same in the storage as in the digester. Many dairy farms separate undigested solids using a solid-liquid separation system (SLS) after the digester. This reduces the volatile solids (VS) loading the effluent storage thus reducing the CH_4 emissions.

Advantages

There are many benefits of farm-based ADS including: renewable energy production, increasing the potential for off-farm sales of by-products, recycling of nutrients, and improving water and air quality. The ADS eliminates CH_4 emissions of all the CH_4 that is contained while also displacing fossil fuel by utilizing the renewable energy.

Considerations

Managing the complex and expensive ADS requires a dedicated management effort. Not all ADS are managed to maximize CH_4 destruction. If excessive CH_4 is allowed to leak or is not combusted and/or if the effluent storage continues to produce excess additional CH_4, the resulting GHG impact may be negative. The potential to emit excess CH_4 exists when 1) ADS leaks occur, 2) the engine-generator set, boiler, and/or or flare are not operated efficiently, and/or 3) if the effluent storage continues to produce uncontained CH_4.

Cost

The costs and benefits of anaerobic digestion are quite complex. Capital costs of turnkey ADS vary but can range from $4,000 to $5,500 per kW of generation capacity. Operating costs from existing systems have been estimated at $0.02 to $0.03 per kWh generated.

Planning considerations

Careful calculations need to be made when planning for an ADS. In particular the utility needs to be consulted to determine how/if the distribution lines to the farm can handle electricity sold. A design professional should be consulted when considering an ADS.

The GWP can be calculated by using Equation 1.2 from Fact Sheet 2 and Equation 1.3 from Fact Sheet 3 along with their respective Tables, 1.2 for methane contributing factor (MCF) and Table 1.3 emission factor (EF3) for N_2O emissions will give the combined GWP for the manure management system. Table 1.10 shows the MCF, EF_3, and GWP as the carbon dioxide equivalent (CO_2eq) per cow per year for a liquid storage without a natural crust and a manure storage system with an ADS where the digestate is followed by a SLS system removing 50% of the remaining VS before a separated liquid storage without a crust. The MCF for an ADS is 0. The MCF of 80 for the effluent storage from an ADS is estimated to be the same as from a liquid storage with an ambient temperature of >82 °F. The ADS would also include solid storage. The separated solids in these systems may be managed in several different ways. Variations in ADS performance and solid storage will change the GWP.
An additional GWP reduction will occur with the production of renewable energy from the engine generator. Assuming a 38 % efficient engine and typical ADS performance, 1,955 kWh of electricity will be produced annually per cow reducing a US average of 1.55 lbs. of CO_2eq/kWh for the fossil fuels avoided (Wright and Gooch). This amount is a reduction in the systems GWP and so is subtracted from the CO_2eq produced from the system.
Additional assumptions used are that: each manure management system stores manure for both the summer period and the winter period, the nitrogen content of the manure excreted is 0.99 lbs./ cow-day, the volatile solids (VS) in raw manure is16.9 lbs./cow-day (ASAE), for the liquid storage without the ADS, SLS will divide the mass of the digestate into 20%

Table 1.10 Global warming potential (GWP) estimates[2] for liquid storage without a crust compared to an anaerobic digestion system, including a solid liquid separation for the digestate, a solid storage for the separated solids, effluent storage for the separated liquid digestate, and fossil fuels avoided

MCF[1] (winter - summer)	EF_3[1]	Manure Management BMP	Annual GWP lbs. from CH_4 CO_2eq/cow/yr.[2]	Annual GWP lbs. from N_2O CO_2eq/cow/yr.[2]	Total Annual GWP lbs. CO_2eq/cow/yr.[2]
(17 – 35)	0	Liquid/Slurry without natural crust	9,213	0	9,213
0	0	Anaerobic Digestion	0	0	0
80[3]	0	Effluent Storage after SLS	03,454	0	3,454
(2 – 4)	0.005	Solid Storage	32	169	202
kWh/cow/year	**lbs. CO_2/kWh**	**ADS Engine Generator**			
1955	1.55	Fossil fuels avoided	(3,024)	0	(3,024)

[1]Source: IPCC (2006) and EPA (2016) [2]Calculated, [3]Estimated to be the same as a liquid storage with an ambient temperature of >82 °F

solids and 80% liquid, SLS will divide the VS remaining after digestion, 5.1 lbs./cow-day, by 50% into each of the solid and liquid storages, the separated solids are stored in a static storage and in this example, the summer ambient temperature is 18°C (64°F) and the winter average temperature is < 10°C (< 50°F).

The total GWP manure management system from an ADS using a SLS on the effluent and storing the solids in a static pile is the digested and separated liquids in an uncovered storage plus the solid storage and subtracting the fossil fuels avoided because of renewable energy production or 3,454 + 202 - 3,024 = 632 lbs. CO_2eq per cow per year. .

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