



Evaluation of Co-Digestion at a Commercial Dairy in Washington State: Progress towards Greater De-centralized Industrial and OFMSW Waste Management

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Anaerobic Digestion

Anaerobic digestion (AD) has increasingly become a commercially sought after manure management technology on US CAFO farms. AD technology allows for manure stabilization, pathogen control, odor reduction, and sequestration of carbon in the form of methane utilization. Additionally, capital and operating costs for the technology are offset by sales from power and co-products; however, the cost of the system is still the bottleneck for wide adoption.



1,000 Cow AD and Co-digestion Operation in Lynden WA

Co-Digestion with Manure

Co-digestion of manure with organic fraction municipal solid waste (OFMSW) substrates is increasingly becoming a common practice at CAFO sites. Co-digestion allows for the potential of increased revenue from tipping fees, increased biogas production, and enhancements in digester stability brought about by improved chemical conditions within the mixed wastewater.

Available Biomass and Treatment Potential

Washington State has 450 dairies totaling 280,000 cows--135 of which are of sufficient size (>500 cows) to warrant immediate consideration for AD installation. These 135 dairies produce 3.8 billion gallons of manure wastewater on an annual basis, representing ~600,000 tons of COD/yr. Co-Digestion can easily handle 20% by volume substrate substitution and thus can treat an additional 760 million gallons of industrial or OFMSW waste that is locally or regionally produced. This represents an additional ~3 million tons of COD/yr.

Co-Digestion Study

A commercial dairy in WA practicing co-digestion was evaluated for one year through weekly sampling. The co-digestion data was compared to a modeled manure-only digestion so that side-by-side comparisons could be made.

Waste Stabilization and Reductions

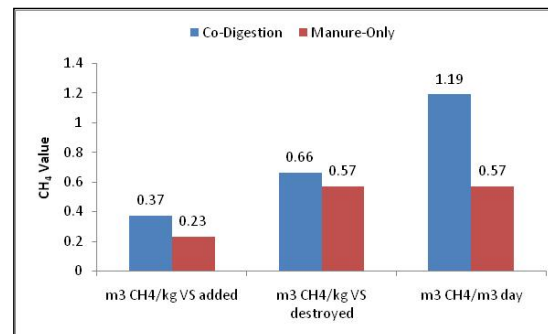
Manure supplied valuable micro-nutrients, alkalinity, and preferred C/N/P ratios and pH. The result was a chemical environment more conducive to AD and capable of overcoming potential product inhibitions. Reductions for co-digestion are higher than previously reported for manure-only. Pathogen reduction were on the order of 2.0 log₁₀ or 99% as indicated by fecal coliform analysis.

Substrate	C/N Ratio	Alkalinity g CaCO ₃ /L	pH	Nutrients N:P:K	Micro-Nutrients Element
Dairy Manure	11:1	9.63 3.22	6.94 0.08	6:1:6	Fe, Mn, S, Mg, Ca, Ni
Substrate*	56:1	3.39 1.40	5.19 0.96	10:1:1	Se, Ni
Co-Digestion	28:1	8.96 1.00	6.87 0.41	8:1:4.5	All

Parameter (g/L)	Influent	Effluent	Mean % Reduction
Total Solids	70.42 ± 12.13	41.82 ± 4.03	40.61
Volatile Solids	59.51 ± 7.49	30.52 ± 3.50	48.71
COD	84.13 ± 15.04	27.16 ± 4.87	67.72
Volatile Fatty Acids	7.71 ± 1.76	0.05 ± 0.02	99.35
Fecal Coliform (cfu/g)	339,031 ± 247,461	3,418 ± 7,060	98.99
Total Kjeldahl Nitrogen	4.12 ± 0.93	3.84 ± 0.53	NA
Total Phosphorous	0.51 ± 0.14	0.44 ± 0.10	NA
Fixed Solids	12.54 ± 1.69	11.35 ± 1.93	NA
Total Ammonia	1.87 ± 0.45	2.65 ± 0.76	+41.71
Potassium	2.31 ± 0.35	2.28 ± 0.27	NA
pH	6.87 ± 0.41	7.88 ± 0.14	+14.37
Alkalinity	8.96 ± 1.00	14.23 ± 1.80	+60.82

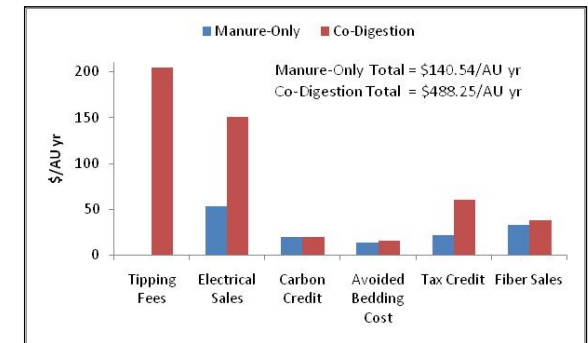
Methane Production

Due to a 48.7% increase in VS and the greater biodegradability of the substrate, the methane productivity nearly doubled as did the volumetric productivity which is a good indicator of added revenue.



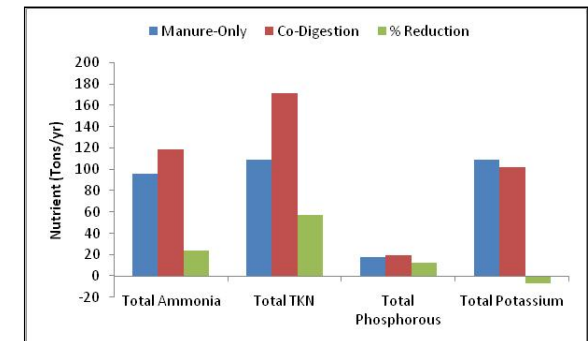
Economics

Substrate addition nearly tripled overall economics and gross receipts generated via tipping fees, enhanced electrical sales and associated tax credits. Nearly 70% of increased revenue was a direct result of the substrate inclusion.



Nutrient Management

A drawback of co-digestion is increased loading of nutrients to the farm and as such can negatively impact nutrient management plans. This shows the importance of nutrient recovery as a part of AD.



Conclusion

Application to the 135 Washington state dairies can result in annual productions and offsets of: 300 million m³ CH₄, 130 MW of electrical power, and 3.2 MMT CO₂; all alongside the important air/water and economic benefits.