



Performance Evaluation of a Modified Plug-Flow Digester Utilizing Scrape Dairy Manure with Co-Digestion

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**VanderHaak Digester
Lynden Washington**

Modified mesophilic plug-flow digester by GHD Inc., and Andgar Corporation utilizing a Caterpillar G398 coupled to a 450 KW Generator

137,700 ft³ reactor with 28,600 gal/day flow containing 18.4% substrate and scrape manure from 695 WCE for a 33.8 day HRT



VanderHaak Digester

- Maximum capacity – 1,500 cows but built on 500-cow dairy
- Manure from additional 250 cows trucked in
- Substrates from local processors @ 18.4% by volume
- Egg Breakage, Fish solids, Food Breeding/Sauce, etc.
- Capital construction cost: \$1,136,364
- Grants covered 38% of investment cost
- Electricity rate (including green tags): \$0.05 per kWh
- Digested fiber used for bedding and sale
- Carbon credits sold on the Chicago Carbon Exchange

Vector Reduction Performance

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	+58.82

Gas Production Performance

Parameter	Units	Co-Digestion	Manure-Only
Total Biogas	ft³ biogas/day	164,178	102,200
Total Biogas	ft³ biogas/ cow* day	197	123
Specific Methane Yield	ft³ CH₄/lb VS_{Destroyed}	15.06	13.46
Reactor Performance	ft³ biogas/ ft³ reactor day	1.19	0.74
Performance Economics	ft³ biogas/ ft³ day/M\$	1.05	0.65
Biogas Composition	%CH₄	63.52	55.9

Co-Digestion Economics

	Manure-Only	Co-Digestion
<i>Gross Receipts</i>	\$/AU yr	\$/AU yr
Tipping Fees	---	192.97
Electrical Sales	68.76	150.37
Carbon Credit	19.68	19.68
Avoided Bedding Cost	12.71	15.25
Tax Credit	27.50	60.15
Fiber Sales	31.78	38.11
Total Revenue	160.43	476.53
Role Substrate % of Revenue	---	66.3

Co-Digestion and On-Farm Nutrients

Nutrient	Manure-Only metric tons/yr	Co-Digestion metric tons/yr	% Change %
Ammonia N	84.9	104.7	23.3
TKN	96.8	151.7	56.7
Total P	15.4	17.4	13.0
Total K	96.4	90.1	-6.5

Economic Scenarios

	<u>NPV</u>	<u>IRR</u>
1. 500-cow herd, electricity & fiber bedding	-\$0.6M	–
2. ADD trucked-in manure from 250 cows	-0.7M	–
3. ADD food wastes	-0.4M	-3.3%
4. ADD tipping fees	1.1M	17.1%
5. ADD sale of excess fiber at \$13.50/cy	1.2M	18.1%
6. ADD carbon credits	1.4M	20.0%
7. Δ to 30-year physical depreciation	2.0M	20.5%
8. Δ to 1,300 cows and no food waste	1.3M	19.3%
9. Δ to carbon trading at ECX price	2.2M	27.4%

Decision making

- Important to design to appropriate size
- Take advantage of multiple revenue streams and co-products
- Co-Digestion, especially with tipping fees, economically +
- Consider role co-digestion has on farm nutrient balance
- Trucked-in manure economically problematic
- Prospects for assuring future viability:
 - Mature carbon credit market
 - Increased value and market for digested fiber
 - Nutrient recovery technology
 - Fuel development, integration with other systems
- Potential as holistic, sustainable conservation technology