Northwest CHP Application Center

Combined Heat and Power for the states of
Alaska, Idaho, Montana, Oregon and Washington
in cooperation with the U.S. Department of Energy

Case Study:
Vander Haak Dairy
Lynden, WA

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925 Plum St SE, Bldg 4 • P.O. Box 43165 • Olympia, WA 98504-3165
(360) 956-2004 • Fax (360) 236-2004 • TDD: (360) 956-2218

Cooperating agencies: Washington State University Extension Energy Program, U.S. Department of Energy,
Alaska Energy Authority, Idaho Department of Water Resources Energy Division,
Montana Department of Environmental Quality Energy Program and Oregon Department of Energy

Vander Haak Dairy Anaerobic Digester

Authored by Dave Sjoding, Kim Lyons and Chad Kruger*

Quick Facts

Dairy Herd Size	1500 cows (3 cooperating dairies)
Type of Dairy Operation	Confined year round – Scraped manure
Manure Transportation	1.5 mile pipe
Digester Type	Two stage – modified mixed plug flow
Digester Volume/Tank size	4,500 gallons/day – Covered insulated tank
Digester Heat	100 degrees – Mesophilic bacteria to make methane
Time for Digestion	22 day cycle
Methane production	58% methane
Prime Mover for Power Production	Modified G 398 Caterpillar engine - Reciprocating
Power Production	300 kWc and 285 kW net energy – can be expanded with turbocharger to 450 kWc
Waste heat used to heat manure	30 – 60 %
Interconnection	Engineering study to triple phase
Pathogen control	99%

Background – Anaerobic Digestion for Dairies – A solution that leads to more solutions

Washington State has approximately 600 operating dairy farms that manage nearly 250,000 dairy cows. These dairies are often identified as sources of odor, water pollution and air pollution, and are under increasing public and regulatory pressure to control these problems. As a result, effectively managing animal wastes is a critical component of dairy operations and can make a difference in the dairy's overall success. Most modern dairies utilize a lagoon system for animal waste storage, a practice that often results in odor problems, due to ammonia and volatile organic compounds (VOCs), and can lead to potential water quality concerns, due to nutrient (nitrogen and phosphorous) runoff, when manure is land applied. A lagoon system can also be a large source for methane and nitrous oxide emissions, both of which are greenhouse gases that contribute to global climate change. The Intergovernmental Panel on Climate Change has estimated that the concentration of methane in the atmosphere has increased by more than 150 percent in the last 250 years.

* Sjoding and Lyons – WSU Extension Energy Program and Northwest CHP Application Center; Kruger – WSU Center for Sustaining Agriculture & Natural Resources

A growing number of dairy farmers are considering anaerobic digesters as an alternative method for managing animal manure. Ideally, these systems mitigate odor problems; protect water quality; reduce greenhouse gas emissions; improve the handling of manure nutrients; control most pathogens; and generate biogas that can be used to produce electricity either for on-farm operations, or for sale into the power grid, or which can be compressed into a liquid fuel. In addition, anaerobic digesters can provide potentially valuable by-products, such as fiber and nutrient water, creating new revenue streams for dairy farms. While these benefits are attractive, producing and managing an anaerobic digestion system is not as simple as operating a manure lagoon and requires a substantial financial and management commitment to be successful.

There are basically three types of anaerobic digesters: 1) Covered lagoon digesters; 2) Complete mix digesters; and 3) Plug-flow digesters. There are also three levels of temperature operating with different bacteria: 1) Ambient (outside air), which is not well suited for our northern climates; 2) Mesophilic (95-105 degrees); and 3) Thermophilic (125-135 degrees). Scrape dairies and flush dairies generally require different specific technologies to do anaerobic digestion. While these systems differ in design, cost, and performance, they all follow the same basic principle where the manure is digested by anaerobic bacteria and converted into a stable effluent and biogas. The biogas generated by the digester contains about 50 to 70 percent methane (600 Btus per standard cubic foot) and can be combusted in an engine to produce electricity. As a rule of thumb for scrapped dairies, modified plug flow mixed mesophilic digesters produce .2 kW per cow per day. Other types of digester systems, operating temperatures and types of animals/feedstock will produce different results. In Washington State alone, using the digester systems such as the Vander Haak dairy, if half of the 250,000 dairy cows were on a farm with anaerobic digestion (AD), as much as 25 MWc of renewable "green" electricity could be generated annually. In addition, as much as 80 million pounds of methane could be captured each year (about 315 thousand tons C equivalent), providing a significant reduction in greenhouse gas emissions. **(Note: calculating actual greenhouse gas reductions are more complicated than presented)**

Bioproducts & Making Economic and Business Sense

Single purpose bioenergy projects (biopower or biofuels) in the Pacific Northwest rarely make business or economic sense on a stand alone basis. Multiple products with multiple revenue streams (including cost offsets) are the key to business and economic success in our region. In this setting, the development of bioproducts assumes major importance. The Vander Haak dairy is no exception. The following is a table of current products, buyers and prices.

Electricity produced – base price	Puget Sound Energy	$.035 / kwh
Green power adder	Puget Sound Energy	$.015 / kwh
Bedding (digested fiber)	Used by the dairies (40-60 % of total)	Offsets sawdust @ ~$10/ton

Compost (digested fiber)	Various buyers	~$3 – 6/ton
Liquid fertilizer	Used by dairies	Substitutes for manure application
Carbon credits	Sold with Environmental Credit Corporation	50/50 split at market price on Chicago Climate Exchange

The following is a table of future products, product development leadership and approximate timeline to completion.

Nursery quality digested fiber (in place of peat moss)	WSU Whatcom County Extension	Peat moss from Canada sells to the nursery industry @ $24+
Crystallized phosphorous fertilizer	WSU Center for Bioproducts & Bioenergy	Potential value TBD

Other products could be developed. For example, subject to water availability, co-located greenhouses can use the extra CO2 rich waste heat (40-70 percent of that produced). In addition, digesters help resolve manure management and odor issues, which in turn can enable larger herd sizes. Piping the manure reduces operating costs. The digester in Tillamook, OR is financially troubled, due to transportation trucking costs.

Vander Haak Dairy

The Vander Haak Dairy is a family run farm operating in Lynden, Washington since 1968. It became the first dairy in Washington State to install a commercial anaerobic digester. The system utilizes a patented plug flow digester, designed by GHD Incorporated of Wisconsin, that handles manure from three dairies and up to 1500 dairy cows (as currently configured). In general, plug-flow digesters have few moving parts and work well with dairies, like Vander Haak, that collect cow manure by scraping instead of flushing the manure with water. The unprocessed manure is collected in a receiving pit and pumped directly into the anaerobic digester vessel where it undergoes a two-stage digestion process. In the first stage, raw manure is mixed and heated to 100^0F, using the reclaimed waste heat from the engine/generator set. This facilitates the growth of acid forming bacteria that breaks down the raw manure into simpler volatile fatty acids and acetic acid. The slurry then gravity feeds into the second stage of the digester where methanogenic bacteria convert the volatile fatty acids into biogas. The second stage of the digester process takes about 20 days, after which the remaining materials flow into an effluent collection pit where they are further processed. The dairy is currently assessing the impact of other available feedstocks on the system processes.

The biogas generated in the digester is collected and burned in a natural gas fueled reciprocating engine set modified to burn biogas. Waste heat from the engine set is recovered and used to heat the digesters (30 to 60 percent is used), and could potentially be used in the future to provide for other thermal needs at the dairy. The engine genset produces about 285 net kW of electricity (parasitic load is 15 kW) which is sold to the power grid. This is enough electricity to serve approximately 180 average homes. The remaining digester effluent is separated into a solid and liquid stream for further processing. The separated solids are currently processed into bedding materials for the dairy or sold to other dairies for bedding. Additional work is underway to develop this material into a compost or soil amendment suitable for sale to commercial nurseries as a replacement to peat moss. The liquid stream from the digester is used as a high-value fertilizer, rich in phosphorous and useable nitrogen.

Financial Structure at a Glance

A number of financial pieces came together to build and operate the Vander Haak digester. Below is a summary table.

Total cost	$1.2 million
USDA 9006 grant funds	$272,000
Vander Haak Dairy, LLC. Private financing	$768,000
WSU Center for Sustaining Agriculture & Natural Resources; Climate Friendly Farming Project	$160,000
Did the bank accept the digester system as collateral?	No
Expected payback period	~7 – 9 years

Key partners and contacts for the Vander Haak Digester Project:

Vander Haak Dairy, LLC; Andgar Corporation; Whatcom County Extension/Whatcom Dairy Biogas Team; Port of Bellingham; Whatcom Conservation District; Whatcom County PUD #1; Puget Sound Energy; USDA Rural Development; WSU's CSANR & Climate Friendly Farming Project (Paul G. Allen Family Foundation)