Washington Dairies and Digesters

Washington State Department of Agriculture

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Cover photos: Dairy cows at Werkhoven Dairy/Washington Dairy Products Commission; In-ground digester at Farm Power Lynden/WSDA; 750 kW engine-generator at Farm Power Lynden/WSDA

This report would not have been possible without the knowledgeable, thorough work of Margaret Drennan in collecting, organizing and articulating the information presented.

WASHINGTON STATE DEPARTMENT OF AGRICULTURE

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Table of Contents

Acronyms used in this report

AD – Anaerobic Digestion
CHP – Combined Heat and Power
CNG – Compressed Natural Gas
DNMP – Dairy Nutrient Management Plan
EPA – U.S. Environmental Protection Agency
RCW – Revised Code of Washington
REC – Renewable Energy Credit
USDA – U.S. Department of Agriculture
WSDA – Washington State Department of Agriculture
WSU – Washington State University

Introduction

For over the past decade, anaerobic digestion (AD) on U.S. dairy farms has been promoted as a technology with both environmental and economic benefits. As one of the nation's top ten dairy states, Washington is considered a prime market for dairy digesters.

Today's dairy AD systems take advantage of a naturally-occurring process in which microbes feed on dairy manure and other biodegradable materials, producing biogas and nutrient-rich effluent that can be separated into solid and liquid portions for different uses.

- The ***biogas*** is about 60% methane and 40% carbon dioxide, with trace amounts of other constituents, and is typically used to generate electricity and heat.
- The ***digested solids*** are often used as bedding for cows, or processed into compost, peat moss substitute, or other soil amendments.
- The ***liquid effluent*** is generally applied to agricultural land to support crop production.

At a production rate of 27 tons of manure per cow per year, Washington's commercial dairies produce more than 6.9 million tons of manure annually[1]. Dairy producers typically use flush or scrape systems to collect the manure into lagoons where it's stored until applied to fields. The manure provides nutrients, particularly nitrogen and phosphorus, needed for crop production.

Anaerobic digestion enhances this manure management system, providing both environmental and economic benefits. On the environmental side, digesters produce renewable energy and reduce greenhouse gas emissions, odor, and pathogens in manure. On the economic side, digester owners can profit from renewable energy sales, tipping fees for taking other organic wastes, and sales of digested solids, carbon credits, Renewable Energy Credits (RECs), and potentially other co-products. Participating dairies may save on bedding costs while still getting nutrients for crop production.

This report includes information about the dairy industry and dairy nutrient management in Washington, as well as brief profiles of the anaerobic digesters installed in Washington that use dairy manure as the primary feedstock. As of July 2011, there were six operating dairy AD systems in Washington using manure from more than eight dairy farms.

This information is presented to provide a resource to those interested in the status of dairy digesters in Washington. Information was compiled in June and July 2011 by the Washington State Department of Agriculture (WSDA). WSDA administers the state's Dairy Nutrient Management Act (Chapter 90.64 RCW), which requires all commercial dairy farms to develop and implement nutrient management plans to protect surface and ground water quality.

Facts about Washington's Dairy Farms

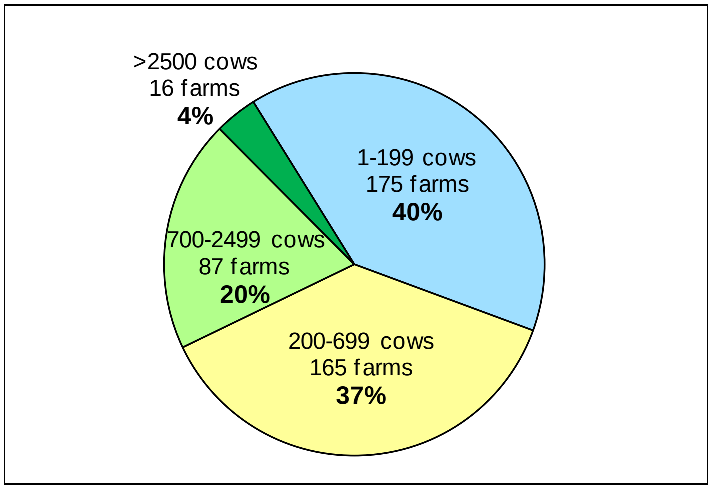
Source: USDA National Agricultural Statistics Service, WSDA Dairy Nutrient Management Program

Milk is Washington's second most valuable agricultural commodity (after apples), with a farmgate value of $950 million in 2010. More than 690 million gallons of milk were produced at Washington dairy farms in 2010, making Washington 10th in the nation in milk production.

Based on 2010 registration data from the WSDA Dairy Nutrient Management program, Washington has 443 commercial cow dairy farms, with more than 250,000 mature dairy cows. Of these, 175 dairies, or 40 percent, are small, with 1-199 mature cows; 165 dairies, or 37 percent, are medium in size, with 200-699 mature cows; and 103 dairies, or 23 percent, are large, with 700 or more mature animals, including 16 dairies that have 2,500 or more cows (Figure 1) [2].

Figure 1. Washington's commercial dairy farms by size

Source: WSDA, 2010 Registration



There are commercial dairy farms in 28 of Washington's 39 counties, but most of the dairies are concentrated in a few areas. Whatcom County is home to the most dairy farms (125 farms and 46,588 mature cows), and Yakima County has the most dairy cows (67 farms and 93,606 mature cows). Most of the large dairies (70 percent) are located in the Yakima Valley and the Columbia Basin; small and medium-sized dairies are typical in western Washington's dairy areas.

The trend in Washington and across the U.S. has been towards fewer, larger commercial dairies, while the total number of dairy cows has remained relatively stable. Here in Washington, the annual average number of dairy cows has ranged between 237,000 and 264,000 head for the last 20 years.

All of Washington's commercial dairies are Grade A dairies, producing milk that is eligible for sale as fluid milk. Milk from Washington's dairy farms is sold as fluid milk and cream or processed into butter, cheese, ice cream, dry milk powder or other products and primarily marketed in Washington and Alaska, and exported to east Asia.

Dairy Digesters in Washington: *An Overview*

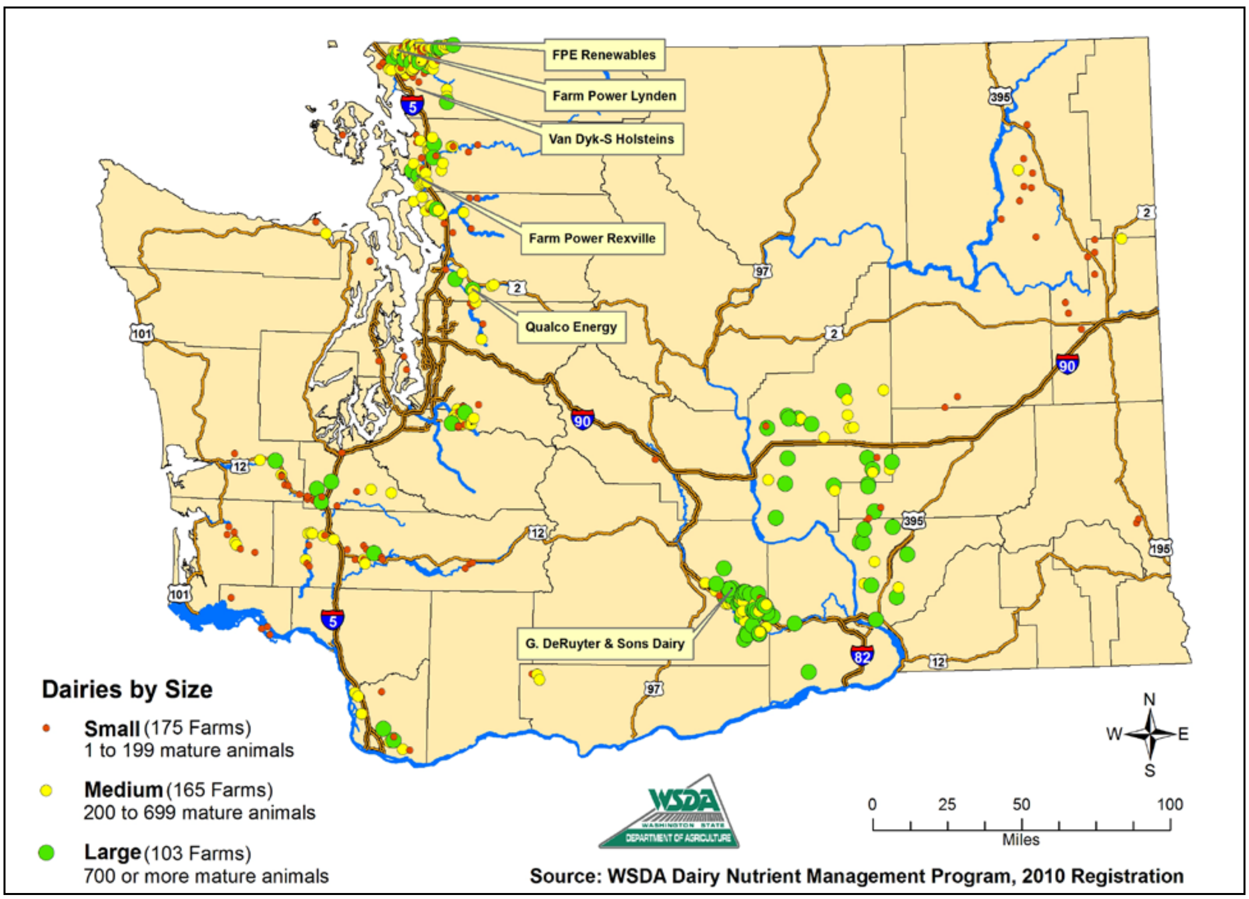
Although anaerobic digestion can be used to process any livestock or poultry manure, all six of the agricultural digesters operating in Washington are located on or associated with dairy farms.

These dairy digesters process manure from about 11,000 cows from Washington's commercial dairy farms and, with the addition of other organic waste, are producing a steady output of up to 4,150 kilowatts of electricity, enough to power more than 2,700 homes, as well as generating other valuable products and benefits. On an annual basis, Washington's dairy digesters capture 2,500 tons of methane, equivalent to more than 50,000 tons of carbon dioxide that would otherwise be released during conventional manure management.

Nationally, EPA AgSTAR[3] estimates that, as of July 2011, there are 142 dairy digesters operating in 26 states, with 88 digesters (62 percent) in the major dairy states of Wisconsin, New York, Pennsylvania, California and Vermont. EPA data shows Washington as 9th in the U.S. in number of dairy digesters.

The first of Washington's dairy digesters started operating in 2004 and, since then, five others have been built. These digesters regularly receive manure from eight Washington dairy farms ranging in size from about 300 mature animals to more than 3,000 mature animals. Five digesters are located in northwest Washington and one is in eastern Washington, in the Yakima Valley. Three digesters are owned and operated by dairies, two are owned and operated by a local private company, and one is a public-private partnership. Figure 2 shows the location of the state's dairies and dairy digesters.

Figure 2. Location of commercial cow dairy farms and dairy digesters, July 2011



Washington's dairy digesters all add varying amounts of other organic materials to the dairy manure in the digester and operate under a regulatory framework that was put in place by state legislation enacted in 2009[4]. This regulatory framework allows dairy digesters to receive pre-consumer, organic waste-derived materials without obtaining a solid waste handling permit if they meet certain conditions. To be eligible for the permit exemption, the feedstock for the digester must be, by volume, at least 50 percent livestock manure and no more than 30 percent pre-consumer, organic waste-derived materials. Non-manure agricultural waste from the dairy can also be used.

In addition, the law specifies the handling and use of the organic waste, digested solids, and liquid effluent so as to address nutrient management, public health and other potential concerns. The permit exemption requires digester design and operation to be consistent with federal standards[5].

Table 1 summarizes some of the key characteristics of the state's dairy digesters. More detailed information about each digester and the partner dairies is provided in the subsequent profiles. Although all operate under the same framework, each digester has different characteristics because of local circumstances and the needs of the digester owners, contributing dairies and other partners.

Table 1. Key characteristics of Washington dairy digesters, July 2011

	FPE Renewables Vander Haak Dairy	**George DeRuyter & Sons Dairy**	**Qualco Energy**	**Farm Power Rexville**	**Farm Power Lynden**	**Van Dyk-S Holsteins**
Business model	Farm own/ operate	Farm own/ operate	Public/ private partnership	Developer own/ operate	Developer own/ operate	Farm own/ operate
Location / County	Lynden, Whatcom	Outlook, Yakima	Monroe, Snohomish	Rexville, Skagit	Lynden, Whatcom	Lynden, Whatcom
Year operational	2004	2006	2008	2009	2010	2011
# Contributing dairies	1*	2	1	2	1	1
# Cows feeding digester	800	5,300	1,100	1,200	2,000	1,000
Additional feedstocks	Pre-consumer waste	Grease trap waste	Pre-consumer waste	Pre-consumer waste	Pre-consumer waste	Pre-consumer waste
Digester design	GHD/Andgar Hybrid plug flow-complete mix	GHD/Andgar Hybrid plug flow-complete mix	GHD/Andgar Hybrid plug flow-complete mix	GHD/Andgar Hybrid plug flow-complete mix	GHD/Andgar Hybrid plug flow-complete mix	DariTech Complete mix
Biogas use	Electricity, digester heating	Electricity, digester heating	Electricity, digester heating	Electricity, digester heating	Electricity, digester heating greenhouse heating	Electricity, digester heating
Installed generator capacity (kW)	600	1,200	450	750	750	400
Receiving utility	Puget Sound Energy	PacifiCorp (Pacific Power)	Puget Sound Energy through Snohomish PUD	Puget Sound Energy	Puget Sound Energy	Puget Sound Energy
Solids use	Bedding	Sold for further processing	Land application	Bedding	Bedding	Bedding
Liquids use	Crop production, Nutrient recovery	Crop production	Crop production	Crop production	Crop production	Crop production
Products currently sold or used by digester	Electricity Heat Solids RECs Carbon credits	Electricity Heat Solids RECs Carbon credits	Electricity Heat RECs	Electricity Heat Solids RECs Carbon credits	Electricity Heat Solids RECs Carbon credits	Electricity Heat Solids RECs

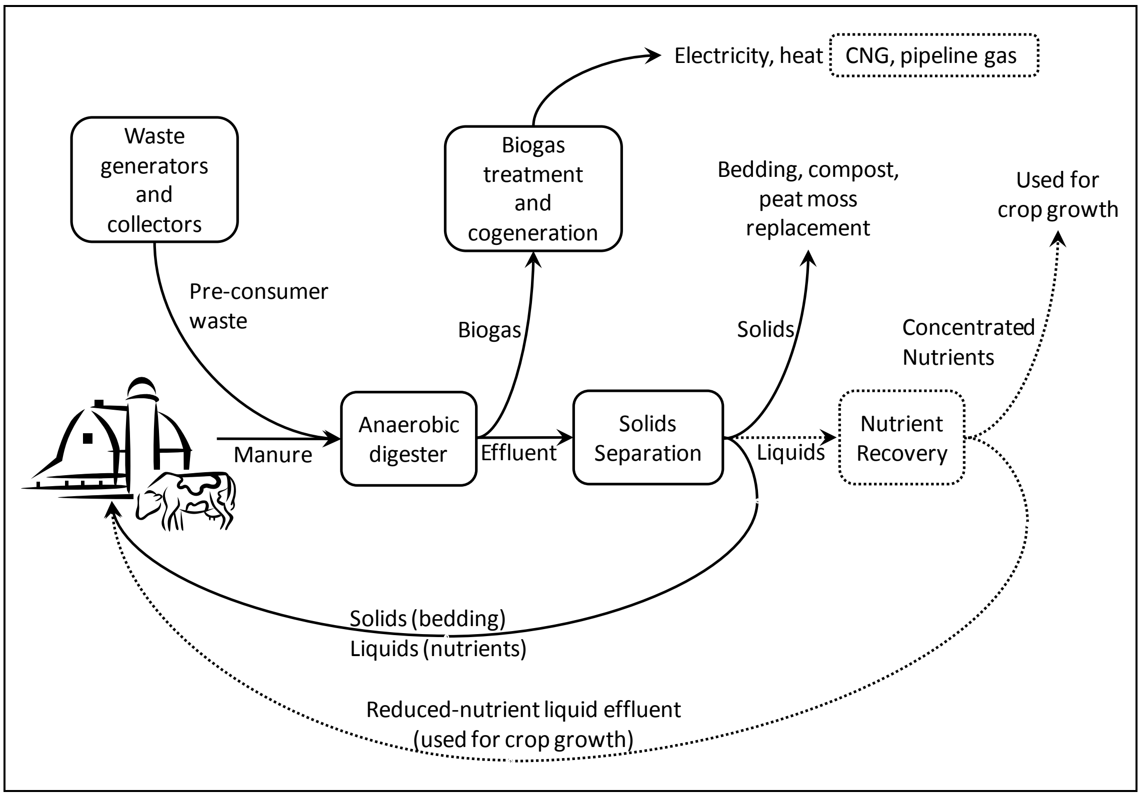
RECs = Renewable Energy Credits * = This digester also regularly receives some manure from a nearby dairy.

Washington's Dairy AD Systems

A wide range of different technologies can be used in anaerobic digestion systems. Generally, for dairy digesters, manure and other biodegradable feedstocks are collected in a vessel where conditions are controlled to maximize the growth of a variety of naturally-occurring microorganisms. Under these conditions (which include controlled temperatures and the exclusion of oxygen), the microorganisms feed on these biodegradable materials and, as a byproduct, produce biogas. This biogas is captured and usually used to generate power and/or heat. Typically, the material exiting the digester is separated into solid and liquid streams.

Figure 3 shows the different steps and products found in varying combinations in the dairy AD systems in Washington. Each of these is discussed in more detail on the following pages.

Figure 3. Dairy AD system with added feedstocks and potential nutrient recovery



CNG = Compressed natural gas

Digester Types

There are two different digester designs currently in use in Washington. A hybrid plug-flow complete mix digester (designed by GHD, Inc. and installed by Andgar) is in use at five of Washington's digesters. The other design is a complete mix digester installed by DariTech. The first full-scale system using the DariTech design began operating in June 2011. Both of these digester designs operate in the mesophilic temperature range, at about 100˚F, which supports good microbial activity and biogas production. There are other options for operating temperature, both higher (thermophilic) and lower (psychrophilic), which have different advantages and disadvantages for biogas production, system stability, and development and operation costs. The vast majority of digesters at U.S. dairies are mesophilic, according to EPA AgSTAR.

Feedstocks

In Washington, all of the operating dairy digesters use a combination of manure and some quantity of pre-consumer, organic waste-derived materials. This co-digestion has a number of advantages. The addition of pre-consumer waste can significantly increase biogas production over dairy manure alone. The increase varies depending on the type and amount of waste used; in one study of a Washington digester, the addition of 20% high-energy pre-consumer waste resulted in a 100% increase in biogas production[6]. Other research on feedstock addition to dairy digesters has shown biogas increases ranging from 25% to 400%[7,8]. In addition to increased biogas production, the operator can collect fees, known as "tipping fees," for receiving these wastes. In some cases, these tipping fees are a digester's single largest revenue source. For the waste generator or collector, contracting with a digester may mean lower tipping fees compared to landfill disposal, reduced transportation costs, and a home for materials that are difficult to dispose of, such as grease trap waste.

Different organic wastes have different potential for biogas production, with manures at the low end of the spectrum. Washington's dairy digesters process a wide range of pre-consumer waste, including whey, eggs, grease trap waste, fish and shellfish processing waste, chicken processing waste, cattle blood, wood processing pulp, cereal wastewater, and unsalable beverages. All these materials produce significantly higher amounts of biogas than dairy manure. Currently, the percentages of pre-consumer waste co-digested at Washington's dairy digesters range from about 5% to close to 30% by volume.

Biogas Treatment and Use

The biogas produced from anaerobic digestion usually consists of 55-70% methane (CH_4) and 30-45% carbon dioxide (CO_2). The biogas also contains trace amounts of ammonia, hydrogen, and hydrogen sulfide. The methane in the biogas can be used to produce electricity and heat, compressed natural gas (CNG), or pipeline gas.

The most common use for biogas is cogeneration, in which an engine produces electricity from the methane while recovering heat. The recovered heat is used to maintain digester operating temperatures, and excess heat can be diffused through a radiator if it is not needed. The carbon dioxide simply passes through the engine. During combustion, the hydrogen sulfide and ammonia in the biogas are converted into sulfur and nitrogen oxides, which are regulated air pollutants. The reduction of hydrogen sulfide (a corrosive compound) is generally desirable, both to meet air permitting requirements and to help preserve engine components. When more biogas is produced than can be burned in the engine, the excess is flared (burned), which converts the methane to carbon dioxide and reduces the impact of releasing the biogas to the atmosphere.

If the goal is to produce gas for pipeline injection or CNG for use as vehicle fuel, then carbon dioxide, hydrogen sulfide, and ammonia in the biogas must all be reduced to very low levels.

Currently, all of Washington's digesters are using cogeneration systems to produce electricity and heat from the biogas. The DariTech digester design accomplishes hydrogen sulfide reduction through a standalone two-step treatment: a microbial process followed by carbon treatment. The Andgar digester design includes a similar biological process, which occurs inside the digester, that reduces the accumulation of hydrogen sulfide in the biogas. None of Washington's digesters are currently converting biogas to CNG, although Western Washington University is conducting research on CNG production at FPE Renewables. Another digester, Qualco Energy, is currently producing more biogas than can be used in its cogeneration system, and is considering whether to install additional cogeneration capacity or to develop CNG production capability.

Nationally, EPA AgSTAR reports that 130 of the 142 dairy digesters are using the biogas for electricity or heat production, or both. One is treating the biogas for pipeline injection, nine are flaring all of the biogas produced, and the biogas use at one digester was not reported. One digester that uses biogas for electricity generation also uses it to generate CNG for vehicle fuel.

Effluent Processing and Use

During digestion, microbes biodegrade a small proportion of feedstock solids into biogas, but due to the high water content of the manure and other feedstocks, the total volume of effluent produced is similar to the total volume of influent.

After digestion, the effluent is separated into liquid and solid components using one or more mechanical processes. Washington's solid waste permit exemption limits how these components can be used:

- Liquid effluent must be returned to a dairy and managed under a dairy nutrient management plan (DNMP) that has been updated to address management and use of the digested materials.
- Digested solids can be returned to a dairy and managed under its DNMP, delivered to a compost facility, or distributed directly to others if they pass compost quality standards.

For the most part, all six digesters return the liquid effluent to the contributing dairies. The liquid effluent is generally stored in lagoons and applied to crop land as needed to supply nutrients for crop production. Most of the digested solids are used by contributing dairies, or sold to other dairies, for bedding. One digester currently sells all of the digested solids to a company that produces a peat moss substitute for wholesale. Three other digesters include an aerobic treatment process that provides additional reductions in pathogens, odor, and microbial activity. Of these three, two are using and selling solids as bedding and one is land applying solids.

Nutrient Recovery

One Washington digester, FPE Renewables, recently added a full-scale nutrient recovery process to its AD system. Nutrient recovery has taken on more importance as adding pre-consumer waste to a dairy digester results in significantly higher nitrogen and more phosphorus than dairy manure alone. Nutrient recovery processes extract some of the nitrogen or phosphorus, or both, from the liquid effluent. There has been great interest in developing nutrient recovery processes, both as a way to better manage nutrients and to develop marketable products that can contribute to the financial feasibility of a digester.

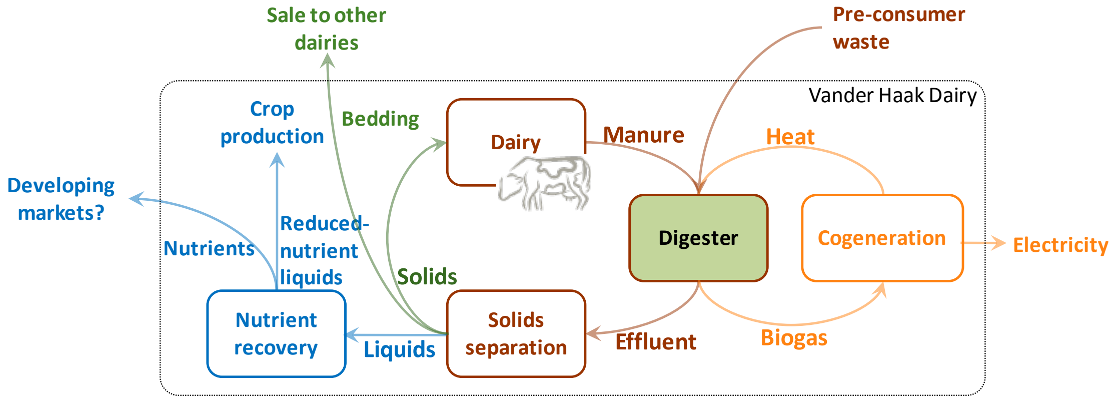
Dairy Digester Profiles

The following profiles of Washington's six dairy digesters were prepared from information compiled primarily during June and July 2011 using a variety of sources, including interviews with digester owners and operators, site visits and information from regulatory agencies and Washington State University (WSU) researchers. Every effort was made to collect and present accurate information, recognizing that there are seasonal variations in operations. Each profile contains a diagram of the dairy AD system in place in July 2011. The profiles also include technical and operational information about the digesters and the contributing dairies that may be of interest.

Profile: FPE Renewables

This farm-owned and operated digester, developed in 2004, was the first in Washington State and has been successfully operated for the past seven years. The original 300/350 kW Caterpillar engine was expanded with a supercharger to a capacity of 400/450 kW, and then replaced with the current 600 kW Guascor engine in 2010. The engine expansion was necessary due to increased biogas production from the addition of pre-consumer waste. Since startup, the digester has been involved in a number of research collaborations and is currently involved in research with both Western Washington University (CNG production) and Washington State University (nutrient recovery, economic feasibility). A full-scale nutrient recovery system has recently started up on site that will treat all of the liquid effluent from the digester, and is producing phosphorous solids and ammonium sulfate.

AD System Diagram



Digester Details

County: Whatcom
Location: Vander Haak Dairy
Contributing Dairies: Vander Haak Dairy, other area dairies

Operation start: November 2004
Digester design: GHD/Andgar hybrid plug flow-complete mix
Herd feeding digester: 800 mature animals
Design volume: 1 million gallons
Total project cost: $1.2 million (original project)
Operator time commitment: 20-30 hours/week

Revenue streams: Electricity, RECs, carbon credits, tipping fees, solids

Influent: Dairy manure, pre-consumer waste
Manure total solids: 3-8%
Retention time: 19 days

Biogas use: Electricity generation, digester heating
Biogas treatment: in-digester sulfur reduction
Receiving utility: Puget Sound Energy
CHP system: 600 kW Guascor

Solids separation: screen, screw press
Solids treatment: none
Solids use: Used by contributing dairy as bedding, sold to other dairies
Liquid effluent use: stored, applied to cropland

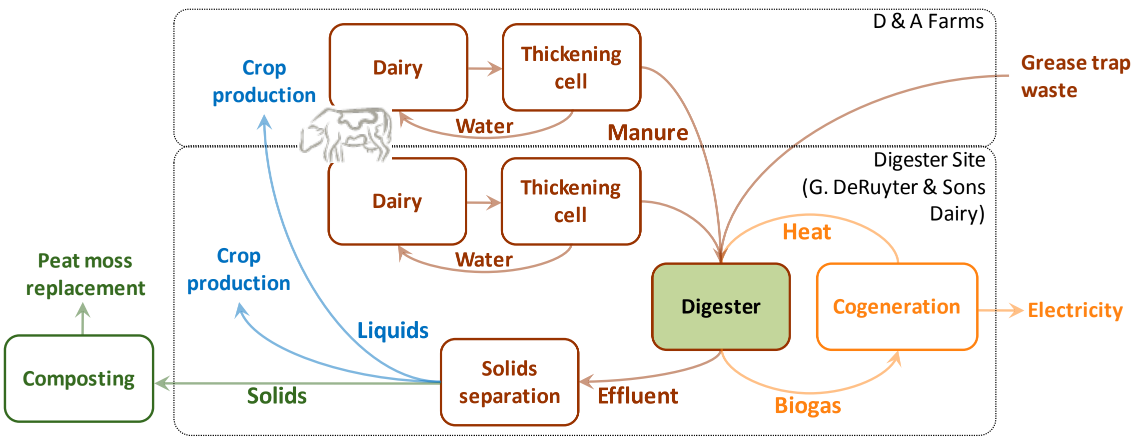
Dairy Facts:

- This digester receives manure piped from four lagoons at the Vander Haak Dairy, and periodically imports manure by truck from nearby dairy farms.
- Digested solids are used as bedding at the Vander Haak dairy and on a number of local dairy farms.
- The dairy has a scrape manure management system.

Profile: George DeRuyter & Sons Dairy

With more than 5,000 mature dairy cows contributing manure, the DeRuyter digester is by far the largest digester currently operating in Washington, and the only one in eastern Washington. It is farm-owned and operated and was developed in 2006. The digester receives manure from two dairies, George DeRuyter & Sons Dairy and D & A Farms. The only non-manure feedstock currently accepted at this digester is grease trap waste, in contrast to the other five digesters that receive a range of pre-consumer waste. Initially, the separated solids were used as bedding or composted on site, but now all solids from this digester are sold to Organix, a Walla Walla company that uses them to produce a peat moss substitute called RePeet™.

AD System Diagram



Digester Details

County: Yakima
Location: George DeRuyter & Sons Dairy
Contributing Dairies: George DeRuyter & Sons Dairy, D & A Farms

Operation start: November 2006
Digester design: GHD/Andgar hybrid plug flow-complete mix
Herd feeding digester: 5,300 mature animals
Design volume: 3.3 million gallons
Total project cost: $3.9 million
Operator time commitment: 18 hours/week

Revenue streams: Electricity, RECs, carbon credits, tipping fees, solids

Influent: Dairy manure, grease trap waste
Manure total solids: about 7%
Retention time: 21 days

Biogas use: Electricity generation, digester heating
Biogas treatment: in-digester sulfur reduction
Receiving utility: PacifiCorp
CHP system: two 600 kW Guascor

Solids separation: screen, roller press
Solids treatment: addition of beneficial bacteria
Solids use: Sale for processing into peat moss substitute
Liquid effluent use: stored, applied to cropland

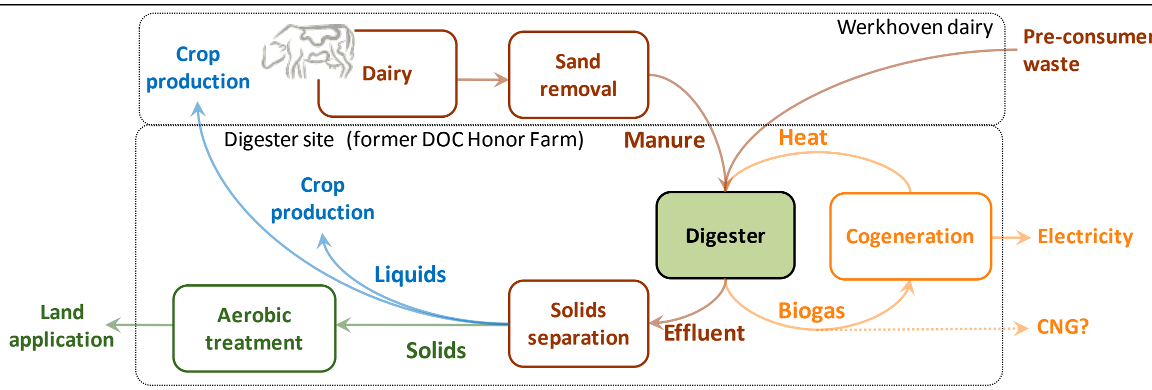
Dairy Facts:

- The digester is located on the George DeRuyter & Sons Dairy, and manure is piped to the digester from the farm's four lagoons and four lagoons at neighboring D & A Farms.
- Both dairies have flush manure management systems.

Profile: Qualco Energy

The Qualco digester, developed in 2008, is a public-private partnership between Northwest Chinook Recovery, the Tulalip Tribe, and the Sno/Sky Agricultural Alliance. Although the digester currently receives manure from only one dairy, the digester was designed with the capacity to partner with several nearby dairies. Biogas production currently exceeds the installed generator capacity and Qualco is considering options to make use of the excess biogas. One possibility is adding a second generator. Another option is installing a system that would clean the biogas and produce CNG for transportation fuel. Research collaborations with WSU and the private company Multiform Harvest have investigated the effects of anaerobic digestion on air quality, pathogens, manure nutrient content, and farm economics, as well as phosphorus recovery in the form of struvite. Solids produced are currently being land applied to improve soil conditions.

AD System Diagram



Digester Details

County: Snohomish
Location: Former Dept. of Corrections honor farm, Monroe
Contributing Dairies: Werkhoven Dairy

Operation start: December 2008
Digester design: GHD/Andgar hybrid plug flow-complete mix
Herd feeding digester: 1,100 mature animals
Design volume: 1.45 million gallons
Total project cost: $3.4 million
Operator time commitment: variable

Revenue streams: Electricity, RECs, tipping fees

Influent: Dairy manure, pre-consumer waste
Manure total solids: about 4-5%
Retention time: 16.3 days

Biogas use: Electricity generation, digester heating
Biogas treatment: in-digester sulfur reduction
Receiving utility: Puget Sound Energy transferred through Snohomish PUD
CHP system: 450 kW Guascor

Solids separation: screw press
Solids treatment: two DariTech Bedding Masters
Solids use: land application
Liquid effluent use: stored, applied to cropland

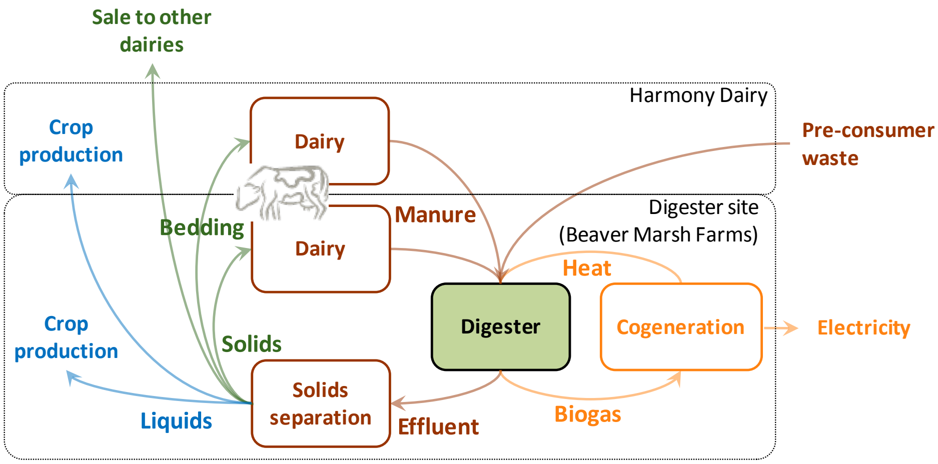
Dairy Facts:

- The Werkhoven Dairy is about 1 mile away from the digester. Manure and digestate is piped to and from the dairy's two lagoons.
- The dairy has a flush manure management system.
- The dairy beds with sand and has a system to remove sand from the manure before it is sent to the digester.

Profile: Farm Power Rexville

Farm Power Northwest is an independent development company that operates and maintains digesters in partnership with nearby farms. This allows a dairy to participate with minimal risk and expense. So far, Farm Power has developed two digesters in Washington and is in the process of developing a third. Farm Power Rexville was the first of the Farm Power digesters; it started operating in August 2009. The digester is located on property at Beaver Marsh Farms, and takes manure from Beaver Marsh Farms and neighboring Harmony Dairy.

AD System Diagram



Digester Details

County: Skagit
Location: Beaver Marsh Farms property
Contributing Dairies: Beaver Marsh Farms, Harmony Dairy

Operation start: August 2009
Digester design: GHD/Andgar hybrid plug flow-complete mix
Herd feeding digester: 1,200 mature animals
Design volume: 1.1 million gallons
Total project cost: $3.5 million
Operator time commitment: about 20 hours/week

Revenue streams: Electricity, RECs, carbon credits, tipping fees, solids

Influent: Dairy manure, pre-consumer waste
Manure total solids: variable
Retention time: 19-21 days

Biogas use: Electricity generation, digester heating
Biogas treatment: in-digester sulfur reduction
Receiving utility: Puget Sound Energy
CHP system: 750 kW Guascor

Solids separation: screw press
Solids treatment: none
Solids use: Used by contributing dairies as bedding, sold to other dairies
Liquid effluent use: stored, applied to cropland

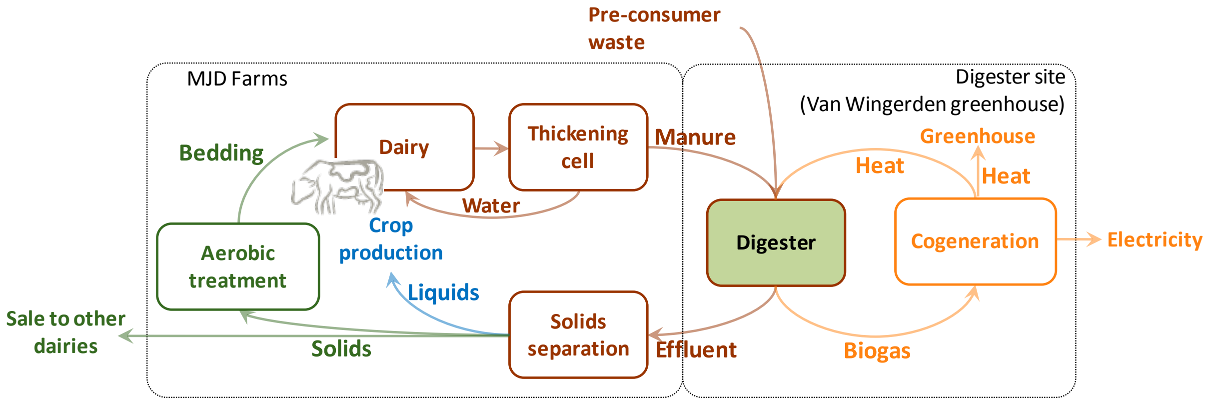
Dairy Facts:

- Manure is piped from two lagoons at Beaver Marsh Farms and one lagoon at Harmony Dairy. Liquid effluent from the digester is returned to both farms.
- Digested solids are used as bedding at both Beaver Marsh Farms and Harmony Dairy, as well as a number of other local farms.
- Both Beaver Marsh Farms and Harmony Dairy have scrape manure management systems.

Profile: Farm Power Lynden

Farm Power Lynden started operating in November 2010 and is unique among Washington's digesters because of the collaboration between the developer and Van Wingerden Greenhouses. The digester and receiving pit are located on property owned by the greenhouse where, in an expansion, Van Wingerden Greenhouses developed a new facility with a radiant floor heating system to take advantage of surplus hot water supplied by the digester. The digester currently receives manure from only one farm, although there are other potential partners in the area. This developer-owned and -operated digester is the second Farm Power project. Manure is piped to the digester from MJD Farms and effluent is piped back; all solids separation occurs at the dairy.

AD System Diagram



Digester Details

County: Whatcom
Location: Van Windergen Greenhouses' property
Contributing Dairies: MJD Farms

Operation start: November 2010
Digester design: GHD/Andgar hybrid plug flow-complete mix
Herd feeding digester: 2,000 mature animals
Design volume: 1.32 million gallons
Total project cost: $4.5 million
Operator time commitment: about 20 hours/week

Revenue streams: Electricity, RECs, carbon credits, tipping fees, solids

Influent: Dairy manure, pre-consumer waste
Manure total solids: variable
Retention time: 19-22 days

Biogas use: Electricity generation, digester heating, greenhouse heat
Biogas treatment: none
Receiving utility: Puget Sound Energy
CHP system: 750 kW Guascor

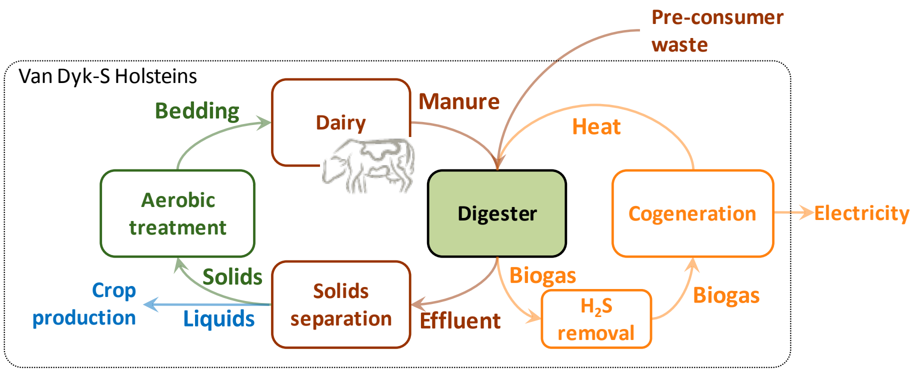
Solids separation: screw press
Solids treatment: Proportion of solids treated with Bedding Recovery Unit
Solids use: Used by contributing dairy as bedding, sold to other dairies
Liquid effluent use: stored, applied to cropland

Dairy Facts:
- Manure is pumped to and from six lagoons at MJD Farms (about 1 mile away).
- The dairy has a flush manure management system.
- All of the solids separation and storage occurs at the dairy.

Profile: Van Dyk-S Holsteins

This digester is the first full-scale demonstration of the DariTech design in Washington. It is an above-ground complete-mix digester with a flexible cover for biogas collection. It's the most recently installed digester in Washington, and started operation in the summer of 2011. In addition to a new digester design, this system also has a standalone two-step process to remove hydrogen sulfide from the biogas.

Diagram of AD System



Digester Details

County: Whatcom
Location: Van Dyk-S Holsteins
Contributing Dairies: Van Dyk-S Holsteins

Operation start: June 2011
Digester design: DariTech Complete mix
Herd feeding digester: 1,000 mature animals
Design volume: 700,000 gallons
Total project cost: $2 million
Operator time commitment: unknown

Revenue streams: Electricity, RECs, tipping fees

Influent: Dairy manure, pre-consumer waste
Manure total solids: 6-7%
Retention time: 22 days (design)

Biogas use: Electricity generation, digester heating
Biogas treatment: microbial hydrogen sulfide reduction
Receiving utility: Puget Sound Energy
CHP system: 400 kW 2G

Solids separation: screw press plus secondary separation
Solids treatment: DariTech Bedding Master
Solids use: Used by contributing dairy as bedding
Liquid effluent use: stored, applied to cropland

Dairy Facts:

- The dairy uses a combination of flushing and scraping to send manure to three lagoons.
- Currently, all of the separated solids produced are used as bedding on site.
- The digester is located on the Van Dyk-S Holsteins property, and manure is piped a short distance from the dairy to the digester. Liquid effluent is returned to the dairy for storage and use.

The Importance of Nutrient Management and Recovery

Dairies in Washington are required to operate under a dairy nutrient management plan and are inspected regularly by WSDA for compliance. One requirement of the DNMP is that the nutrients in the manure (both nitrogen and phosphorus) are applied to crop fields in the right time, place, and form for good crop production as well as for protection of both ground and surface waters. Dairies also must have sufficient capacity to properly handle and store manure and wastewater on site. Inspections include a full review of records for nutrient applications and crop production as well as a review of storage and facility conditions and management.

Dairy AD systems in Washington have created new challenges for managing dairy nutrients. Adding pre-consumer waste to dairy digesters not only increases biogas production but also can significantly increase the amount of nitrogen when compared to manure only. The addition of pre-consumer waste can also increase the phosphorus content in the effluent. Under the solid waste permit exemption, these increased nutrient levels need to be quantified and incorporated in the receiving dairies' DNMP so that their field applications of nutrients are balanced with crop production. This can be a challenge as the type and volume of organic feedstocks can vary considerably during the year as well as from one year to the next. This variability requires the dairies to stay in close touch with the digester operator and to increase nutrient testing of the digestate in order to stay within agronomic rates. So far, Washington dairies receiving liquid effluent from digesters have had to obtain additional land and adjust cropping to make use of the increased nutrients. In some cases where additional land is not available, dairies are exporting excess nutrients to other crop growers.

The anaerobic digestion process converts much of the nitrogen in the feedstocks from organic forms to inorganic forms (ammonia). Ammonia is more readily taken up by plants, which is a benefit. However, ammonia is also more susceptible to volatilization during storage or application. This also requires additional attention by the dairies to minimize potential water and air quality concerns.

Researchers in Washington have partnered with digester owners and private companies to develop ways to recover nitrogen and phosphorus from manure and liquid effluent. Nutrient recovery can significantly reduce the amount of nutrients a dairy needs to manage. It can also create a range of new opportunities for marketing those nutrients to other growers.

Nutrient Recovery in Washington

<u>Nitrogen and Phosphorus Recovery</u>: A full-scale commercial installation of a system that recovers both nitrogen (in the form of ammonium sulfate) and phosphorus (in the form of phosphorous solids) from dairy AD effluent is now operating at FPE Renewables. The system can be operated to produce ammonium sulfate, phosphorous solids, or both. In pilot-scale tests, recoveries of both phosphorus and nitrogen were as high as 80%. A second nutrient recovery system based on this design is planned at Rainier Biogas, a digester under development near Enumclaw. The system was developed based on WSU research; the full-scale system resulted from collaboration between researchers and Andgar.

<u>Phosphorus Recovery as Struvite</u>: Phosphorus recovery from livestock wastewater in the form of struvite has been demonstrated in other parts of the country. A pilot-scale test at the Qualco Energy digester has demonstrated successful struvite recovery from dairy digester effluent, reducing total phosphorus in the effluent by 60-80%. Current collaborative research efforts by WSU and Multiform Harvest include further process development to reduce costs, improve the struvite particle size, and further tailor the process for effective performance on dairy manure.

Washington Dairy Digestion Potential

As of July 2011, manure from four percent of the cows on Washington's commercial dairy farms was being processed at dairy digesters and, with the addition of other organic waste, was producing a steady output of up to 4,150 kilowatts of electricity, as well as a range of other valuable products and benefits described in this report. This dairy digester activity is just a fraction of what may be possible.

Expanding digester development in Washington taps into the potential to produce a significant amount of renewable energy and provide tools to manage dairy nutrients and protect water quality, while bringing economic benefits to dairies, digester owners, and a variety of related businesses.

Nationally, there is a major push to increase anaerobic digestion on the nation's dairy farms.

- In May 2010, EPA and the U.S. Department of Agriculture signed an agreement to promote renewable energy generation and slash greenhouse gas emissions from livestock operations by expanding technical assistance and outreach to help overcome obstacles to digester development.
- In a December 2010 report, EPA AgSTAR estimated that opportunities for biogas capture and use exist at more than 2,600 dairy farms across the US, including 125 dairy farms in Washington.
- In May 2011, the national dairy industry announced a goal to have 1,300 anaerobic digesters operating across the country by 2020.

According to EPA AgSTAR, the potential for positive financial return appears to be most likely at dairy operations with milking herds of at least 500 cows and anaerobic lagoons or liquid slurry manure management systems. While herd size is an important factor in determining digester potential, many other factors come into play, including location, potential markets for electricity, heat or CNG, local utility interest, existing infrastructure, options for manure movement and management, and farmer interest. In particular, utility policies and low electricity pricing in Washington make project financing more difficult. Washington's average retail electricity price of 6.6 cents/kWh in 2009 was well below the national average of 9.82 cents/kWh[9].

Regulatory Factors

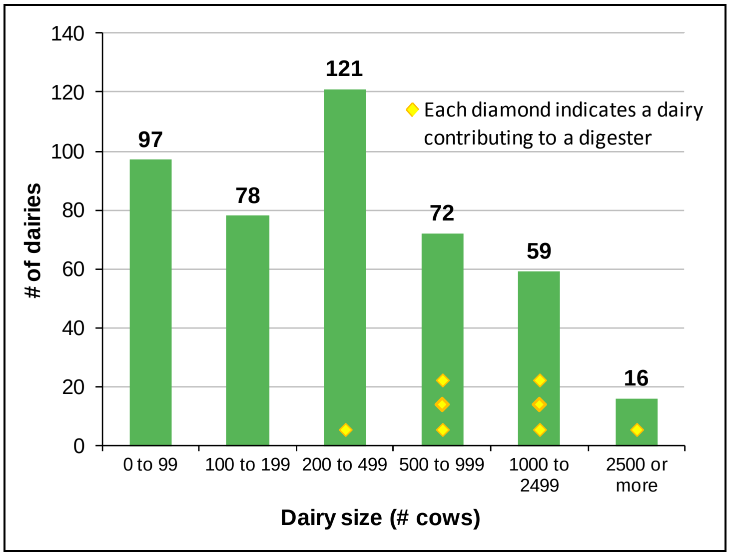
The regulatory environment has also been a factor as WSDA and other agencies consider how to carry out their responsibilities when presented with the growth of dairy AD systems in the state. Permitting requirements and other regulatory aspects related to digesters are in a state of evolution at both state and local levels. Regulations related to land use, zoning, water quality, air quality, solid waste management and dairy nutrient management may all come to be important factors during digester development. Regular communication among the agencies, the dairy industry, digester developers, and university researchers have helped in bringing issues and possible solutions to light and in working towards coordination of approval and permitting processes and regulatory consistency. For example, local health jurisdictions, conservation districts, the Department of Ecology and WSDA continue to work together on implementing the requirements surrounding the solid waste permit exemption that the six dairy digesters operate under.

Changes in technology or in digester operations – some digesters are looking to expand feedstocks beyond the limitations of the solid waste permit exemption – are likely to trigger further discussion and regulatory decisions about environmental and public health issues that will affect development.

Dairy Size and Anaerobic Digestion

Though EPA AgSTAR uses 500 cows as the threshold for digester potential, Washington's experience indicates that a farm with less than 500 cows can successfully contribute to a centralized digester. Figure 4 shows Washington's 433 commercial dairies by size, with yellow diamonds indicating the size category for the eight dairies that currently contribute manure to the six digesters.

Figure 4. Washington dairies by size, noting dairies contributing to a digester



All of Washington's current digesters use manure from at least 800 cows, and the next dairy digester planned in Washington is a multi-dairy digester that plans to take manure from three or four dairies that each have 300 to 500 cows (see box below).

WSU research and technical assistance has been instrumental in developing the digester systems operating in Washington today, with important work on digester design, co-digestion, nutrient recovery, economic feasibility, feedstock characteristics, nutrient management, biogas purification, and more. There is continuing focus on improving the feasibility of dairy digesters at medium and small dairies. Research areas include the development of lower cost digester designs and increased options for on-farm biogas use.

Potential Growth in Digesters by 2020

Washington's experience with dairy digesters indicates a range of successful approaches. Based on the rate of development in Washington to date, an additional 6 to 9 dairy digesters could be expected to start operation by 2020. Of course, whether these digesters used manure from 100 cows or 5,000 cows would make a big difference in their impact.

This projected future growth may be a very conservative estimate. As the environmental benefits of digesters are realized, as financial, policy, and regulatory hurdles are overcome, and as technology and markets for co-products mature, dairy digester development may become more rapid in Washington.

In Development: Rainier Biogas

Rainier Biogas, the third digester project in Washington by Farm Power Northwest, is under development in King County, near Enumclaw. Construction has not started yet but, when finished, this digester is intended to take manure from at least three nearby dairies (about 1,500 cows) and to accept other pre-consumer waste feedstocks. The design is a GHD/Andgar hybrid plug flow-complete mix with a 1 MW cogeneration system. The plans include a nutrient recovery system similar to the system recently installed at FPE Renewables.

Information for Future Digester Operators

Here are some insights, from WSDA conversations and work with current dairy digester operators, that may be useful for future projects.

Development

- Careful planning and organization are key to success.
- Negotiating the different permitting processes can be a major challenge during development.
- Failure to apply for required permits can seriously delay the completion and operation of a project.
- A good relationship with a cooperative power utility is essential to negotiating power purchase agreements (both duration and price), intertie agreements, and potential transfers to another utility.
- Plan ample time for dairy nutrient management plans to be updated. No non-manure feedstock can be used in the digester until the updated DNMPs are approved.

Operations

- Manure handling systems (especially pumps) are the most prone to failure. Build in redundancy to minimize the effect if these systems fail.
- Minimize costs by doing your own maintenance as much as possible.
- To be successful you have to rely on a variety of revenue streams. Flexibility in marketing different products allows operators to weather changes in feedstock availability or low power prices.

Other Types of Anaerobic Digestion in Washington

Anaerobic digestion can be used to produce energy from a wide range of biodegradable materials, including municipal biosolids, a wide range of food wastes, and even municipal solid waste. This report focuses on anaerobic digestion at dairies, but AD also takes place at municipal and industrial wastewater treatment facilities in Washington.

Municipal Wastewater Treatment: The state's largest wastewater treatment facilities have anaerobic digestion systems, although not all of them are using biogas for electricity or heat production. Anaerobic digestion with energy generation is taking place at both the King County South and West Point plants and at LOTT in Olympia. These plants use the biogas for electricity production, plant heating, or both; the biosolids are land applied as a soil amendment, or used to produce compost or potting mixes.

Industrial Wastewater Treatment: According to a company news release, the J.R. Simplot potato processing facility in Moses Lake installed a 20 million gallon digester in 2007 that treats wastewater on site. The biogas produced is used to heat process water, reducing the plant's natural gas use.

Municipal Organics Treatment: There are two digesters for post-consumer organics currently in the planning stage in Washington: one at the Cedar Grove composting facility in Snohomish County, and the other at Barr Regional Bio-Industrial Park in Lincoln County.

References and Endnotes

Information used in this report is from the following sources:

Dr. Keith Bowers, Multiform Harvest

Digester operators at FPE Renewables, George DeRuyter & Sons Dairy, Qualco Energy, Farm Power Northwest, and Van Dyk-S Holsteins

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Professor Craig Frear, Washington State University

United States Department of Agriculture, National Agricultural Statistics Service

Washington State University, CSANR Research Report 2010-001, 2010

Washington State Department of Agriculture, Dairy Nutrient Management Program

Endnotes

[1] ASAE Standard D384.2, Manure Production and Characteristics, American Society of Agricultural Engineers, March 2005.

[2] The three size categories correspond with the U.S. Environmental Protection Agency categories for dairies under the federal Concentrated Animal Feeding Operation (CAFO) rules.

[3] AgSTAR is a collaborative program between EPA, the U.S. Department of Agriculture, and the U.S. Department of Energy with the objective of supporting anaerobic digestion systems for livestock manure management. http://www.epa.gov/agstar/

[4] SSB 5797 was enacted as Chapter 178, Laws of 2009. The specifics of the regulatory framework are codified in RCW 70.95.330. The Department of Ecology and local health departments have regulatory oversight for AD co-digestion facilities under the state's solid waste law. The guidelines for digesters operating under the exemption are available at http://www.ecy.wa.gov/pubs/0907029.pdf.

[5] USDA Natural Resources Conservation Service (NRCS) Conservation Practice Standard 366, Anaerobic Digester

[6] C. Frear, W. Liao, T. Ewing, and S. Chen. 2011. Evaluation of Co-Digestion at a Commercial Dairy Anaerobic Digester, *Clean – Soil, Air, Water*, **39**(7): 697-704.

[7] F. Alatriste-Mondragón, P. Samar, H. H. J. Cox, B. K. Ahring, and R. Iranpour, R. 2006. Anaerobic Codigestion of Municipal, Farm, and Industrial Organic Wastes: A Survey of Recent Literature, *Water Environment Research* **78**(6): 607-636.

[8] R. Braun, E. Brachtl, and M. Grasmug. 2003. Codigestion of Proteinaceous Industrial Waste, *Applied Biochemistry and Biotechnology* 109: 139-153.

[9] United States Energy Information Administration, State Electricity Profiles 2009