On-Farm Anaerobic Digestion Educational Mission

Vermont, USA

October 20 – 22, 2008

REPORT

BRITISH COLUMBIA
The Best Place on Earth

This mission would not have been possible without the generous help and support from several people and groups. Special thanks are owed to David Dunn (Central Vermont Public Service Corporation and creator of Cow Power) for helping to create such an excellent agenda. Thanks are also owed to Paris Thomas (BC Milk Producers Associations) for helping to organize the attendee list, the BC Innovation Council for sponsoring the bus, and the Investment Agriculture Foundation and the BC Agriculture Council for assisting with trip expenses through the Agriculture Environment Initiative.

ON-FARM AD EDUCATIONAL MISSION REPORT

INTRODUCTION

Last summer, a group of 21 participants organized by the BC Ministry of Agriculture and Lands spent a week visiting anaerobic digesters in Switzerland, Austria and Germany. During this week, participants were able to witness the versatility and practicality of Anaerobic Digestion (AD) while gaining first hand experience of daily operations.

Although the trip was a valuable exercise, one limitation was that the facilities visited were not operating in an economic or regulatory environment similar to that currently in BC.

Therefore, a second educational mission was organized for farmers, energy providers and pertinent regulatory bodies to see on-farm digesters in an economic and regulatory environment similar to BC's.

This 20 participant mission (see Appendix A for participant list) visited three commercial on-farm digesters, two experimental on-farm digesters, a wastewater digester and Ben & Jerry's ice cream factory in Vermont, from October 20th – 22nd, 2008 (see Appendix B for agenda).

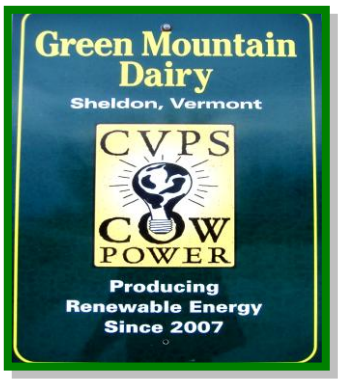
During the mission participants were able to see operational and experimental digesters, speak to those who have helped develop Vermont's AD industry, and meet farmers / food processors that own or are involved with the operation of digesters. This enabled participants to gain a greater understanding of:

- The types of feedstock used for energy production in Vermont,
- The types of digester and engine technologies used in Vermont and their advantages / disadvantages,
- The problems and solutions associated with grid connectivity in rural Vermont,
- The policies, regulations and economic incentives that have enabled AD to become economically viable in Vermont and why / how they occurred,
- The odour reduction benefits of AD to Vermont's dairy farms,
- The use of digestate for on-farm bedding and fertilizer, and
- The farmer's personal experiences with AD.
- Furthermore, this mission enabled pertinent farmers, ministries, associations, crown agencies and energy providers to share ideas on how to make on-farm AD a reality in BC.

COMMERCIAL ON-FARM SITE VISITS

1. Green Mountain Dairy Farm *(Sheldon)*

Green Mountain Dairy is one of the largest farms in Franklin County with 1,050 cows (900 milking and 150 dry cows) on site. The farm produces over 20 million lbs / 9 million kgs of milk and 10 million gal / 38 million L of manure annually. The farm harvests 800 acres / 320 ha of corn and 400 acres / 160 ha of grass in Sheldon, Swanton and Highgate.



All farms selling Cow Power proudly display their credentials

Quick facts

- Digester and genset provider: GHD Inc. and Martin Machinery.
- Digester design and size: Plug flow 112 ft long, 72 ft wide and 16 ft deep.
- Feedstock: 27,000 gal / 102,000 L manure a day and 4,000 gal / 15,000 L Ben & Jerry's waste every third day.
- Digester temperature and retention time: 38^{o}c for 21 days.
- Total cost: US $2.37 million (US$ 256,000 for a power line to the farm).
- Funding: US $755,000 in grants (32% of costs).
- Date came on-line and started selling Cow Power: March 2007.
- Predicted payback: 6 years.
- Biogas scrubbed: No (cheaper to repair genset).
- Electricity generation: 1,700 MWh a year sold to the grid.
- Thermal energy use: Some is used to heat the digester and produce hot water, the rest is exhausted to the outside air.
- Digestate use: Liquid digestate field spread, solid digestate used for bedding within few days of production (saving the farm US $100,000 in sawdust costs annually) or sold for US $10 yard^3 / US $9 meter^3 to local farms.
- Animal health: Since installing the digester somatic cell counts have fallen.
- Nutrient management plan: Yes.
- Lessons learned: Experience has been a good one and the farmer has no regrets.

2. Blue Spruce Farm *(Bridport)*

Started in 1956 with just 30 cows, today Blue Spruce Farm has 1,200 cows (1000 milking) and produces approximately 24 million lbs / 11 million kg of milk and 13 million gal / 49 million L of manure annually. In an effort to sustain their farm business, maximize revenue potential and reduce odour, the Audets explored the potential of on-farm AD.

All 3 farms visited use GHD plug-flow digester technology

Quick facts

- Digester and genset provider: GHD Inc. and Martin Machinery.
- Digester design and size: Plug flow 112 ft long, 76 ft wide and 14 ft deep.
- Feedstock: 35,000 gal / 132,000 L manure a day and two loads of whey a week.
- Digester temperature and retention time: 38°c for 21 days.
- Total cost: US $1.3 million (a lot of construction was done by farm employees).
- Funding: US $350,000 in grants (27% of costs).
- Date came on-line and started selling Cow Power: January 2005.
- Predicted payback: 7 years.
- Biogas scrubbed: No (cheaper to repair genset).
- Electricity generation: 1,400 MWh a year sold to grid.
- Thermal energy use: Some is used to heat the digester and produce hot water for the dairy operation, the rest is exhausted to the outside air.
- Digestate use: Liquid digestate field spread, solid digestate used for bedding within few days of production (this has played a large part in making the digester profitable) or sold to local farms and a local composting company for sale regionally www.moodoo.com for more information).
- Animal health: Since installing the digester somatic cell counts have fallen.
- Nutrient management plan: Yes
- Lessons learned:
  - Two gensets are better than one (reduces the cost of genset downtime),
  - Always have spare parts around as delivery can take a while, and
  - Odour reduction has been hugely popular with neighbours / farm owners.
- Additional info: Will experiment with lakeweeds as a potential feedstock in 2009 and is a partner on a prototype algae production system (see www.algepower.com for more information).

All 3 farms visited use the dry digestate for bedding

3. Pleasant Valley Farm *(Richford)*

Built in 1998, today Pleasant Valley Farm produces over 40 million lbs / 18 million kg of milk and 16 million gal / 60 million L of manure annually from its 1,500 milking cows. The farm also crops 3,500 acres / 1,400 ha. Although the farm is not in CVPS electric service territory, in 2006 the utility signed a contract to purchase the renewable energy attributes from the farm.

All 3 farms visited use Martin Machinery gensets

Quick facts

- Digester and genset provider: GHD Inc. and Martin Machinery.
- Digester design and size: Plug flow 220 ft long, 76 ft wide and 16 ft deep.

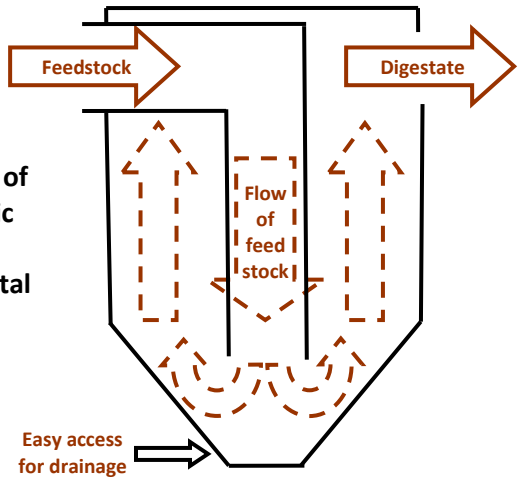
- Feedstock: 47,000 gal / 177,000 L manure a day and 12,000 gal / 45,000 L Ben & Jerry's waste every week (plans to increase this).
- Digester temperature and retention time: 38°c for 21 days.
- Total cost: US $2.3 million.
- Funding: US $650,000 in grants (28% of costs).
- Date came on-line and started selling Cow Power: November 2006.
- Predicted payback: 7 years.
- Biogas scrubbed: No (cheaper to repair genset).
- Electricity generation: 3,500 MWh a year sold to grid.
- Thermal energy use: Some is used to heat the digester and produce hot water, the rest is exhausted to the outside air. Future plans to make the necessary plumbing changes to take advantage of exhausted heat in other areas.
- Digestate use: Liquid digestate field spread, all solid digestate used for bedding within few days of production (this has saved the farm US $150,000 annually).
- Animal health: Since installing the digester somatic cell counts have fallen and the heavier bedding has proven beneficial to the cows.
- Nutrient management plan: Yes.
- Lessons learned:
  - Has been one of the best things the farmer has done as it provides a more reliable income than milk (due to the fluctuating prices of milk), and
  - Grid interconnection was a little frustrating.
- Additional info: Ben & Jerry's are not charged a tipping fee, although they do handle and cover all delivery costs.

EXPERIMENTAL ON-FARM SITE VISITS

1. Nordic Farm *(Shelburne)*

In 1999, The Vermont Agency of Agriculture, Food and Markets and the Vermont Public Service Department began a joint venture to determine why AD was not in widespread use throughout Vermont. While the venture's initial objective was to build a few AD demonstration sites, this objective soon shifted to identifying and assisting farmers in overcoming hurdles to widespread adoption. One aspect of this work was to design a digester that would possess a minimal number of easily accessible parts and would need minimal adjustments as well as including as many off-the-shelf items as practical.

In the fall of 2005, an experimental digester was constructed at Nordic Farm (a 240 cow farm). The digester uses a pump and grinder system to feed the manure through an external heat exchanger prior to feeding it into the digester every 10 to 15 minutes (to increase energy production and minimizes the chance of top-crust formation). The heat exchanger is a concrete tank with aluminum tubing that utilizes waste heat from the genset to heat the incoming manure to approximately 38°C before entering the digester.



Schematic of the Nordic Farm's experimental digester

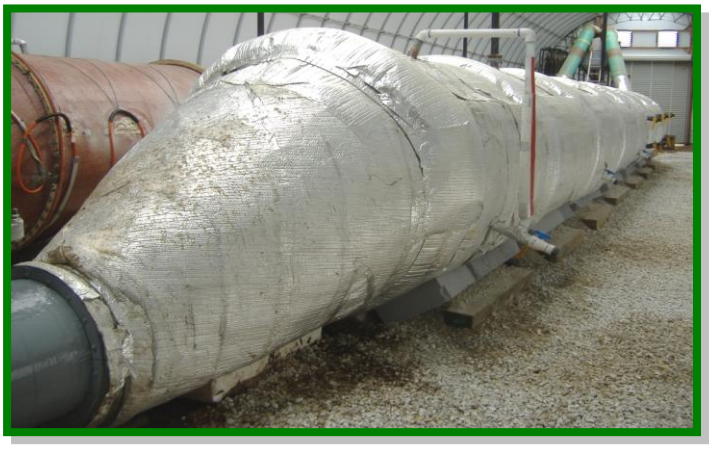
Quick facts

- Digester and genset provider: Experimental glass / steel (Harvester Silo) digester and Martin Machinery genset.
- Digester design and size: Vertical plug flow (See previous diagram) 31 ft tall and 28 ft wide with no mechanical agitation (as manure digests it becomes less dense and floats to the surface).
- Feedstock: Manure from the farm (plans to use whey in the future).
- Digester temperature and retention time: Digester not heated (manure heated to 38^{o}c before entering digester) for 25 - 30 days.
- Total cost: US $350,000 (with significant labour provided by Vermont Agency of Agriculture Staff and consultant Stan Weeks).
- Funding: US $100,000 from Agency of Ag. (29% of costs).
- Date came on-line: Fall 2005 (not selling Cow Power as all energy used in a Net Metered system on farm).
- Predicted payback: 7 – 8 years and rising (due to increased maintenance costs).
- Biogas scrubbed: No (cheaper to repair genset).
- Electricity generation: 0.35 MW a year.
- Thermal energy use: Only used to heat the manure.
- Digestate use: Field spread.
- Nutrient management plan: No.
- Lessons learned: Last summer, due to rising sawdust prices, straw was used to bed the cows and this plugged the digester. To have a successful on-farm digester, farm employees must be educated about the technology.
- Additional info: As many parts as possible were designed to be external to the digester, facilitating easier access for cleaning and repair.

Nordic Farm's experimental digester

2. Foote Farm *(Ferrisburgh)*

Conventional wisdom has it that at least 500 head of cattle are required to justify the cost of installing a typical on-farm plug flow digester.



Avatar's experimental modular plug-flow digester

However, this is a belief that Dr. Guy Roberts from Avatar is hoping to disprove by designing a cost-effective digester specifically for manure from as few as 80 – 200 head of cattle. The prototype digester consists of six-feet-long and eight-feet-wide modular components that can be manufactured in a factory and shipped to the farm (where they can be assembled and easily handled by existing on-farm equipment). This means that the digester can be assembled, and similarly disassembled for cleaning, relocation or reconfiguration, with a minimal number of required labour and specialized contractors.

Quick facts

- Digester: Avatar experimental design.
- Digester design and size: Plug flow expandable / contactable above ground design with no mechanical agitation (agitation to prevent crust formation is possible via several portholes near the end of the digester and a portable "trash" pump).
- Feedstock: Manure from the farm (is capable of accepting chopped straw).
- Digester temperature and retention time: Manure heated before entering digester, heating coils used to maintain temperature at 38°c for 18 – 21 days (retention time will increase if digester is extended with additional sections).
- Total cost: Predicted to be around US $150,000 – US $200,000 for a 100 cow system.
- Predicted payback: Unknown.
- Electricity generation: A 20 kW engine is on order.
- Digestate use: Liquid digestate can be field spread and solid digestate can be used for bedding.
- Lessons learned: Due to portability, banks will likely be more willing to provide favourable loans to build the digester (easier to repossess).
- Additional info: Predictions are that the digester will require cleaning in the first 3 years, and thereafter every 5 or 10 years (more frequently if sand is used for bedding).

Inside Avatar's experimental plug-flow digester

COMMERCIAL OFF-FARM SITE VISITS

1. Essex Wastewater Treatment Facility *(Essex Junction)*

Despite being widely adopted at large wastewater treatment facilities, methane-based electricity generation is generally not considered cost-effective for smaller facilities. However, this presumption has clearly been disproven by Essex Junction's 2 million gal / 7.6 million L a day Waste Water Treatment Facility (WWTF), where two 30 kW "Capstone" microturbines were successfully installed in 2003.

Essex WWTF's microturbines run on both methane and natural gas

Interested in electricity generation since 1992, no project was implemented because of the facility's governing board payback requirements (seven years) and uncertainty around digester temperatures (could it still be maintained while running the microturbines?). Instead, Essex Junction WWTP utilized half the methane gas produced through AD to fire a boiler (to heat the digesters) while flaring the rest to reduce greenhouse gas emissions.

However, this all changed in 2003 because of two key developments. First, to satisfy the payback requirement, US $80,000 in funding was obtained from Efficiency Vermont, The Biomass Energy Resource Center, NativeEnergy and the U.S. Department of Energy. Second, to allay concerns around digester temperature, Essex Junction teamed up with Northern Power to design microturbines that can run on both methane and natural gas in parallel (with methane the priority fuel).

Today the facility runs its two 30 kW micro turbines for 48 total hours each day, producing approximately 0.4 MW a year. This production has helped reduce the facilities energy needs by roughly 36%, saving Essex Junction approximately US $37,000 annually.

Quick facts

Inside one of Essex WWTF's digesters

- Genset provider: Northern Power.
- Digester temperature: 38^{o}c.
- Total cost: US $300,000.
- Funding: US $80,000 in grants (27% of costs).
- Date came on-line: October 2003.
- Predicted payback: 6.9 years.
- Biogas scrubbed: No (cheaper to repair genset).
- Electricity generation: 0.4 MW a year.
- Thermal energy use: Used to heat the digester.
- Digestate use: Some field spread by local farmers.
- Lessons learned: Essex Junction has learned a lot from this project and are willing to share their experiences with other facilities looking at doing the same.

CONCLUSIONS

AD is an off-the-shelf technology that is becoming widely adopted throughout Vermont. This adoption has helped Vermont dairy farmers increase and diversify their revenue streams, improve their animal's health, reduce on-farm greenhouse gas emissions and nutrient runoff into local water resources, and overcome rural – urban odour related conflicts.

Adoption of AD has provided multiple benefits for Vermont's dairy farmers

AD adoption remains a definite possibility for BC farmers, and while each farm may have different feedstock types and volumes in different environments, there are likely to be many similarities between each farm. These similarities were evident in Vermont, where all three commercial on-farm digesters visited:

- Use plug-flow mesophilic digester technology (to ensure the digestate is suitable as a bedding material for the cows),
- Do not clean the biogas before it enters the genset (due to gas cleaning costs being higher than engine replacement costs),
- Use the dry digestate as animal bedding (saving the farm $'000s a year in sawdust costs),
- Import off-farm organic waste to boost on-farm energy output,
- Follow a nutrient management plan to ensure a healthy balance of on-farm nutrients,
- Have been unable to utilize all of the thermal energy generated during electricity production, and, most importantly,
- Have taken advantage of financial programs for on-farm renewable energy technologies (such as higher energy prices paid by CVPS through Cow Power and publicly available grants).

Cow Power (See Appendix C) is a voluntary program in which Central Vermont Public Service (CVPS) customers (both residential and businesses) can voluntarily sign up to pay an additional 4 cents / kWh for the electricity they consume. All 4 cents of this premium is passed directly to the farmer.

The grants, which have come from a multitude of sources, including U.S. Department of Agriculture, Vermont Department of Public Service's Clean Energy Development Fund, CVPS and the Vermont Agency of Agriculture, have helped cover around 30% of the total construction costs. These incentives and grants have been instrumental in lowering the payback period of on-farm digesters in Vermont to between 6 and 7 years.

BC farmers can learn from the experiences of our friends in Vermont. Adoption of similar practices, technologies and operations will help move AD from theory to reality in BC.

However, until the following changes are made, it is unlikely that on-farm AD will become widespread in BC. These changes are:

- Establishment of clear provincial rules and regulations for bringing off-farm waste onto farms for AD (with associated nutrient management plan),
- Recognition of biogas energy production as a standard farm practice and modification of all applicable documents related to Agricultural Land Reserve use to reflect this recognition, and
- Increased AD-specific Federal and Provincial financial incentives (in the form of higher biogas energy payments, grants, etc.) to reduce the risk of building a digester / payback period.

Furthermore, unlike in Vermont, more consideration must be given on how best to fully use the thermal energy generated during electricity production. Ideally, this resource should only be exhausted to the outside air in extreme circumstances.

Daisy hopes to produce Cow Power when she grows up.

APPENDIX A Participants (alphabetically)

1. **Joe Bifano:** Dairy Farm President and Manager (Nata Farms Inc.),
2. **Sean Darling:** Director, MAL/ILMB Climate Action Team (BC Ministry of Agriculture & Lands and Integrated Land Management Bureau),
3. **John Dejonge:** President (Artex Barn Solutions),
4. **Matt Dickson:** Bioenergy and Carbon Offset Policy Advisor (BC Ministry of Agriculture & Lands),
5. **Arlene Fernandez:** Life Sciences Sector Specialist (BC Innovation Council),
6. **Cornelis Hertgers:** Dairy Farm Owner and Past President (BC Milk Producers Association),
7. **Heather Holley:** Director, Regulatory Reform, Straightforward BC (Ministry of Small Business & Revenue),
8. **Alistair Johnston:** Director of Manufacturing (Vitalus Nutrition Inc & Vanderpols Eggs Ltd.),
9. **Erik Karlsen:** Chair (BC Agricultural Land Commission),
10. **Dick Klein Geltink:** Dairy Farm Owner and President (BC Milk Producers Association),
11. **Colette Lekborg:** Trade Commissioner (Canadian Consulate General, Boston),
12. **Ken Ross:** Resource Planning Manager (Terasen Gas Inc.),
13. **Ken Schwaerzel:** Dairy Farm Owner,
14. **Paris Thomas:** Director of Communication and Planning (BC Milk Producers Association),
15. **Alex Tu:** Office of the Chief Technology Officer (BC Hydro, Office of the Chief Technology Officer),
16. **Alisa Williams:** Environmental Management Analyst (BC Ministry of Environment),
17. **Thomas Wynker:** Dairy Farm Partner,
18. **Bill Vanderkooi:** Dairy Farm Owner, Founder and Manager (Nutritech Solutions/Nutrifood Solutions)
19. **Ian Vantreight:** Greenhouse Owner (Vantreight Farms), and
20. **Tony Werner:** Dairy Farm Owner.

APPENDIX B On-farm AD Educational Mission Agenda

Date	Location / Activity	Notes

Mon 20th	• Greeting and brief background to educational mission.
	• Presentation by Lieutenant Governor.
	• Presentation by Secretary of Agriculture.
	• Presentations on AD:
	  ○ building Vermont's first digester in 1982: experience and lessons learned.
	  ○ Vermont Methane Project: what was it, why was it done, who was involved and what were the results?
	• The Cow Power program (www.cvps.com/cowpower):
	  ○ Concept, development process & intended purposes.
	  ○ Results, success and future plans.
		• Matt Dickson (MAL).
		• Lt Gov. Brian Dubie
		• Sec. Roger Allbee.
		
		• Robert Foster (Foster Bros. farm).
		• Robert Ide (Agency of Transportation).
		• David Dunn (CVPS Cow Power) & Mike Raker (AEC).

	Site Visit: Green Mountain Dairy Farm. • Under ownership of Brian & Bill Rowell for 10 years, today the farm produces over 20 million pounds of milk / yr from its 1,050 milking cows. • The digester accepts food waste from a Ben & Jerry's ice cream manufacturing facility and came on line in March 2007. Today it sells 1.8 MWh / yr to Cow Power.	• Green Mountain Dairy, 962 Morey Rd, Sheldon, VT. • Brain and Bill Rowell. • Billie Davis (Ben & Jerry's).
Tue 21st	**Site Visit:** Nordic Farms (Agency of Agriculture). • Visit experimental AD site utilizing the Vermont Agency of Agriculture's "silo" design.	• 1211 Ethan Allen Hwy, Shelburne, VT. • Stephanie Zehler.
	Site Visit: The Foote Farm. • Visit Avatar research project using a prefab fibreglass 80 cow module digester.	• 2665 Mt. Philo Rd, Ferrisburgh, VT. • Dr. Guy Roberts.
	Site Visit: Blue Spruce Farm. • Started in 1956, today Blue Spruce farm produces approx 24 million pounds of milk / yr from its 1,200 milking cows. • The on-farm digester produces 1.3 MWh / yr and started selling cow power in January 2005. • The digester will experiment with lakeweeds in 2009.	• 1796 VT Route 22A, Bridport, VT. • Contacts: Marie Audet. • Contact: Gail Bush (Algaepower experiment).
Wed 22nd	**Site Visit:** Pleasant Valley farm (Berkshire Cow Power). • Constructed in 1998, today Pleasant Valley farm produces 40 million pounds of milk / yr from its 1,500 milking cows. • While not in CVPS territory, the digester produces 3.5 MWh / yr and started selling cow power on in Nov 2006.	• 1546 Richford Rd, Richford, VT. • Contact: Amanda St. Pierre.
	Site Visit: Ben & Jerry's. • Tour of Ben & Jerry's ice cream factory.	• 1281 Waterbury Stowe Rd, Waterbury, VT.
	Site Visit: Essex Wastewater Treatment Facility. • Facility produces an average of 30,300 ft^3 methane / day. • In October 2003, two 30 kW Capstone combined heat and power microturbines were added. This project has reduced yearly electricity costs from $100,000 to $63,000.	• 39 Cascade St, Essex Junction, VT. • Jim Jutras.

APPENDIX C Cow Power Program

Since October 2004, Central Vermont Public Service's (CVPS) Cow Power program has been helping Vermont dairy farmers build economically feasible on-farm digesters. Under this program, CVPS customers (both residential and businesses) voluntarily sign up to pay an additional 4 cents / kWh for the electricity they consume. When signing up for Cow Power, customers can choose 25%, 50% or 100% of their electricity to be enrolled in the program. Under the 100 percent plan, a CVPS customer using 500 kWh per month pays an extra US$20 each month. Residential and small business customers can discontinue this participation at any time, while large business customers must sign for at least three years.

CVPS signs a five-year contract with each farm (which can be renewed for five more years at the farm's request) and passes the 4-cent premium directly to the farmer along with 95% of the market price for the electricity the farmers sell to CVPS. While rates have varied, typically farmers have received a total payment of between 10 and 12 cents / kWh. Under Cow Power, the farms are responsible for any costs associated with installing new poles and wires, and the electric system upgrades that allow safe grid interconnected operation of the generation system.

Currently demand for Cow Power exceeds supply (in October 2008 farms were supplying 63% of total demand). When this happens the 4 cent premium is used to purchase renewable energy credits, or, if none are available, CVPS deposits the payments into the CVPS Renewable Development Fund. This fund provides grant money for farmers to help pay for some of the digester construction costs and funds a full-time project coordinator to help farmers through the evaluation, selection, and construction process.

Currently, four Vermont farms are producing Cow Power, with a fifth expected to be online before the end of 2008 and three new ones expected to come online in 2009. By the end of 2010, CVPS hopes to have a dozen farms online and between 7,500 and 10,000 customers enrolled (currently it has approximately 4,000 customers, which is 2.5% of total customer base).