A Changing Business Model at Iron Creek BioGem Plant

Heightened interest and awareness in biogas technology began in the late 1990s in Western Canada as a result of several important changes in the agriculture industry. The trend towards confined feeding operations was creating large, concentrated quantities of manure. The implementation of provincial legislation regarding the expansion and construction of confined feeding operations was forcing producers to look for sustainable manure management systems. The ratification of the Kyoto Protocol by the federal government in late 2002 raised interest in technologies that reduce greenhouse gas emissions. Lastly, rising energy prices heightened interest in manure management systems that facilitated “waste to energy” practices.

Iron Creek Hutterite Colony

The Iron Creek Hutterite Colony is located south of Viking, Alberta. The Hutterites are a religious group living communally in rural North America. They are a people with strong commitment to self-reliance and self-sufficiency. The Iron Creek Hutterite Colony provides for over 80 people and is self-sustaining through agriculture, including crop and livestock production. In 2001, the Colony generated large quantities of manure from a 700 sow, farrow to finish operation, 650 ewes and offspring, 5,000 broiler chickens, 2,100 layer chickens and 1,000 cattle. This was a growing waste problem that required a solution that would appease the surrounding community and reduce odour and environmental contamination.

In 2001, water was in short supply at the Colony because there was no local water pipeline, the water wells on-site produced insufficient water to meet demand and attempts at drilling for water were unsuccessful. As a result, the Colony was hauling water at a significant cost and started looking for ways to conserve or recycle this valuable resource. In addition to the need for water, the Colony had a tremendous demand for power and heat. Due to escalating costs for natural gas, the Colony changed most of their heat supply over to coal-fired boilers. In 2001, the Colony’s electricity bills were a staggering $250,000.

With plans in place for the construction of a slaughterhouse facility, the Colony closely examined their electrical requirements and costs and searched for a solution. The secretary at Iron Creek toured several livestock operations in Belgium, Holland and Germany to see how biogas technology was used. After seeing the success of biogas as an alternative energy in Europe, the Colony recognized an opportunity for energy self-sufficiency. The desire for energy self-sufficiency, rising energy costs, waste management concerns and a water shortage were the main drivers in the adoption of biogas technology.

BioGem Power Systems

At the same time, environmental concerns and odour issues were causing delays in construction of large barns, slowing business for electrical contractor Grant Meikle. In search of a manure management solution that could help relieve this delay, the success and large-scale implementation of biogas technology in Europe stood out as a promising option. In 2000 Grant and others formed BioGem Power Systems of Ponoka, Alberta and secured the North American rights to a proprietary European technology that uses anaerobic digestion in a series of digesters to produce biogas. The European technology is from Roman Welter and Fils, Luxembourg. Shortly afterwards, Iron Creek Hutterite Colony partnered with BioGem in the construction of Alberta's first commercial biogas system to produce methane from manure and sell electricity into the provincial grid.

The Iron Creek Digester System

Construction on the plant began late in 2001 and was complete within four months. The Colony was directly involved, supplying any labour required during the construction phase. The system installed at Iron Creek is a complete mix digester, suitable for handling wastes that are low in solids (<10 %). The plant was sized to accommodate manure from a 1,200 hog farrow to finish system. This would accommodate expansion of the hog operation as well as allow the incorporation of slaughterhouse waste and alternative straw bedded manures including sheep, cattle and poultry.

Manure is flushed into a 15 m by 5 m receiving tank where solids are chopped to reduce particle size before being sent to one of three digesters. These circular concrete digesters, $1000m^3$ in size, were constructed below ground. The flow of waste from the receiving tank into the digesters is computer controlled and metered to record the exact amounts entering each tank. $88m^3$ of waste enters and leaves the digester daily in this continuous feed system. The computer control system senses gas concentrations and automatically adjusts flow rates, mixing and other operational parameters to maintain constant conditions and uniform gas production.

To achieve optimum digestion, the waste remains in the digester for 20 to 30 days depending on feedstock characteristics, flow rates, biogas production and quality. The digester contents are mixed using a propeller mounted in the side of the digesters that may be pulled to the top for ease in servicing. Mixing is semi-continuous and computer controlled.

The Colony made the decision to construct the digesters below ground to minimize heat loss. This required a lot of earth moving and resulted in some settling problems for production lines. Experience shows that the system generates ample heat to accommodate sub-zero temperatures in winter months without any problem and, in hindsight, there was no benefit to burying the digesters.

The receiving tank is heated to 30°C and digesters are heated to 37°C using water heated through a heat exchanger using waste heat from the electricity production process. An estimated 2 % of the thermal energy produced is used to maintain the proper operating temperature of the digesters. Motorized valves open and close to allow the hot water to be circulated through the digesters using heating coils. The digesters are double walled with an insulated core so heat loss is minimal.

An expandable rubber bladder fits tightly over the digesters, capable of expanding up to 4.5 metres above the tank to trap the gas that is produced. One time the rubber bladder tore due to extreme spring winds experienced at the plant. This was not necessarily a technological problem but reinforces the fact that every technology requires adaptation to the specific setting in which it is applied. A 20 foot high wind fence was constructed around the plant to reduce wind speed and prevent future tears.

Biogas from all three digesters is blended and piped to the engine area. Biogas production from the manure is approximately $30m^3/m^3$ waste. Methane content of the biogas ranges from 60-75 % depending on the feedstock blend. There are no problems with the variability in the gas quality as this is regulated by computer and the extent of the load applied to the engine. The plant generates 350 kW of electrical energy and 770 kW (2.7GJ) of thermal energy using a Deutz engine and generator set. An emergency radiator is on-site in the event that the waste heat cannot be used.

BioGem's trade secret is in the elimination of hydrogen sulfide production, a corrosive and poisonous by product of most systems. This technology does not create H_2S so expensive scrubbers to remove this gas are unnecessary. The result is a unique plant with low maintenance and reduced operating and capital cost.

The situation at Iron Creek also demanded a more advanced system of wastewater recovery. A half-million dollar intensive water recovery process known as 'Welclean' was designed to remove and treat the liquid fraction of the digested waste. Using a combination of primary filtering and reverse osmosis, solids are removed and the liquid is purified to meet and exceed recreational water standards.

Operating at full capacity, the purification system can produce up to 25 gallons per minute. This process recycles 70 % of the water used in the livestock operations. The remaining nutrient rich solid fraction is used as a biofertilizer. Although this system was very costly, the expense of water hauling at this site made the investment worthwhile. By using recycled water as wash water the Colony is once again able to keep up with domestic demand.

As planned since the construction of the biogas plant, the Colony installed a slaughterhouse facility, producing an alternative waste stream with significant biogas potential. Animal offals and mortalities must be pre-processed before they can be digested. The Colony purchased a used grinder for $70,000 that is suitable for handling bone, hides and tough connective tissue. The grinder selected was of old-fashioned design, making it simple, effective and easy to maintain. It is rated for 40,000 kg/hr and operates at maximum speed of 625 rpm.

Although this grinder usually runs off a 150 hp electrical motor, the Colony modified it to run off the power-take off of their 425 hp tractor. The grinder was likely oversized for the amount of waste generated, but it is the most effective for grinding the bone and hides of whole frozen hogs. If the mortalities are not frozen, the hide poses a problem in the grinder. Mortalities must be frozen or skinned before use. It is anticipated that the addition of these materials will significantly boost the methane production and improve the overall economics of the plant.

Operational Challenges

Colony members are independent thinkers and constantly strive to maximize profits. Upon drilling in search for water, a source of natural gas was discovered on the property and in the Colony's attempts to boost electricity production, the engine was destroyed. The plant ran without problem for about 2.5 years, despite temperatures as low as -40°C until this natural gas disaster in the summer of 2004. Since that time, the plant has not operated. Negotiation between Iron Creek and BioGem was necessary before the plant could start up again. The negotiation culminated in a revision to the business and operational model to prevent against future situations.

Originally the Colony did maintenance, but under the new plan BioGem (now known as Open Energy Sources) will provide regularly scheduled maintenance and technical and operational support. Support will provide remote monitoring and monthly reporting of critical information including gas production, waste volume treated, electricity sold and revenue generated. It is hoped that this new model will secure the future success of the Iron Creek plant and ease the process of adoption for other livestock producers choosing to explore this waste management strategy. The plant is scheduled to begin production again in late April, 2006 with no major changes to the original system.

Electricity Sales

It took eight months of negotiation with the utility company to establish the Iron Creek facility as an independent power producer, permitting them to sell electricity directly to the grid. This was perceived to be a streamlined process, but it was soon discovered that there was a lack of communication between different departments of the line holder company that considerably slowed the permitting process. As this plant was the first of its kind to explore the possibility of the sale of electricity into the grid, the requirements and regulations were not clearly defined. The recommendation from this experience is that a liaison between the independent power producer and the line holder is needed to determine and relay the permitting requirements and ensure/enforce that these requirements are met.

Power generation is the largest revenue stream, making the economic viability of a bio-digester highly dependent on the current price of natural gas and electricity. The sale price for electricity on average is 6.5¢/kWh but can be as high as 10¢/kWh during peak periods. About 35 % of the electricity produced will supply the demand on-site.

Project Financing

The pilot plant at Iron Creek demonstrates that biogas technology is a simple concept and can be successful without a high degree of complexity and a large price tag. Maintaining a low capital cost is particularly important given Alberta's competitive energy market. The plant at Iron Creek was jointly funded by the Colony and Open Energy with capital costs estimated at $2 million (not including the wastewater recovery system). This plant was 100 % privately funded with no government support, although Open Energy welcomes any government support available on future initiatives.

Financial Viability

Because there is no legislation requiring livestock operators to employ this technology, revenue streams and savings generated using the technology must offset the capital and operating costs of the technology. Capital costs are offset by selling electricity into the provincial grid as well as cost savings on manure injection, water, heat and electricity.

System optimization is achieved by running the generator at peak hours. The colony is able to stop electricity generation depending on the time of day and the price of power so at night, when the cost of power is low, the generator is shut off and the colony obtains power from the provincial grid. Revenues from the sale of electricity generated by the plant are $96,000 per year.

The biogas plant provides additional savings of $145,000 for electricity and $203,000 for heat each year. Heat savings are calculated used a landed natural gas price of $8.70/GJh. An additional $60,000 saving is realized by the Colony though the recycling of water. The Colony eliminated its yearly bill of $100,000 for manure injection. The cost for manure injection was very high because some of the manure had to be trucked 25 km for spreading. Given energy prices at the time of construction, the pay back period was estimated at 4.1 years for this plant.

Operational costs are kept to a minimum at this site. Total plant operational costs are estimated at 2¢/kWh ($61,320/yr) which includes the cost of maintenance for the entire system and diesel costs (used for ignition). Computer control and remote monitoring reduces the labour costs associated with a facility this size. Only one individual needs to check the system twice per day. The technology selected eliminates the need for expensive H_2S removal through a proprietary process. There are no transport costs or potential tipping fees associated with this plant as all waste is generated on–site.

Summary of Financial Considerations

Capital Cost	$2,000,000
Average Electricity Sale Price	$.065/kWh
Operating and Maintenance Costs	$.02/kWh
Plant output	350kW, >3,000,000kWh/yr
Annual Revenues for Electricity	$95,645 /yr
Annual Savings in Electricity	$145,102 /yr
Annual Savings in Manure injection	$100,000
Annual Savings in Heat	$202,954 /yr
Annual Savings in Water Hauling	$60,000

Estimated Payback Period*	4.1 years

*Payback is based on electrical and heating revenue and savings as well as by accounting for reduced operating costs.

A carbon credit trading system may be in place in 2006, so offsets may be a potential source of revenue in the future. At this time, the plant is not calibrated to determine the tons of carbon dioxide equivalents produced/reduced. Bio-fertilizer products can help offset the implementation costs. The Colony considered the potential market for compost sales but is not currently exploiting this opportunity. The colony feels that one of the biggest benefits is not measured in dollars, but in odour reduction.

Iron Creek Biogas Plant Summary

Business proposition:	To provide a simple and economically efficient technology for the production of electricity from livestock manure on a Hutterite Colony in Alberta.
Type of plant:	Complete mix, single-stage mesophilic digestion, 350 kW Deutz engine.
Feedstock:	Primarily hog manure with option to incorporate straw bedded cattle, sheep and poultry manure as well as offal and mortalities.
Reactor dimensions:	3-1000m^3 concrete digesters (16m diameter and 5m high) sunk below ground
Feed rate:	88m^3 per day, continuous feed
Operating temp.:	±37°C, mesophilic
Dry matter:	<10 %
Retention time:	20-30 days
Agitation:	Horizontal stirrer operated semi-continuously
Biogas production:	±30m^3 biogas per m^3 manure
Methane content:	60-75 %
Sulphur (as H_2S):	To treatment required (proprietary process)
Cost of plant:	$±2,000,000 CAD
Energy output:	350 kW electrical, 770 kW thermal >3,000,000 kWh electricity per year
Waste Heat Usage:	2 % used to heat digester and the rest used to heat barns and other buildings on site, 2,572,754 btu/hr utilized within barns, no purchasing of natural gas
Wastewater management system:	Advanced wastewater system used at this site: ‘Welclean’ process removes solids (spread as fertilizer) and purifies water (used as process and wash water), cost

	estimated at $500,000 CAD