RENEWABLE ENERGY

What is Bioenergy?

Biomass energy, or bioenergy, refers to all forms of renewable energy that are derived from plant materials produced by photosynthesis. Biomass fuels can be derived from wood, agricultural crops and other organic residues. These fuels can be obtained from many sources in Canada, including sawmills, woodworking shops, forest operations and farms.

Case Study

Biomass Combustion Systems

Schurman Farm Ltd.
Heating a Pig Farm and Other Integrated Farm Heat Loads

Biomass Combustion Systems
Spring 2001

The recent upward trend in oil and gas prices has caused many Canadian business owners to reflect on the finite nature of fossil fuels and to take another look at renewable sources of energy such as solar, wind and biomass. Many are discovering that renewable energy technologies today are well developed and reliable.

The Schurman Farm Ltd. Biomass Combustion System was constructed in the original farm workshop because of its central location.

Bioenergy is regarded as "green" energy for several reasons. Assuming that biomass resources, such as forests, are managed properly, biomass fuels are infinitely renewable. They have already proven to be economically stable sources of energy over time. Bioenergy is neutral in terms of carbon dioxide (CO_2) emissions. The burning of biomass fuels merely releases the CO_2 that the plants absorbed over their life spans. In contrast, the combustion of fossil fuels releases large quantities of long-stored CO_2, which contributes directly to climate change. Using bioenergy displaces fossil fuels and helps slow the rate of climate change.

Commercial wood heating is common in rural areas across Canada. Between 1980 and 1993, many businesses and institutions in the Atlantic provinces installed automated biomass heating plants to stem rising energy costs. Despite relatively low oil prices in the last decade, many businesses have continued to operate – and often expand – their biomass heating plants. They have achieved significant savings and other benefits from low-cost bioenergy.

This case study features one of several small businesses that have installed a biomass combustion system (BCS).

Introduction

Schurman Farm Ltd. is a large, farrow-to-finish hog farm near Kensington, Prince Edward Island. Owner Lea Schurman has had a long-standing interest in low-cost renewable energy. In 1985 he installed a round-bale straw burner to heat the farm workshop and the family home. With the growth of the farm operation to 330 sows, Lea needed more heat. In 1993 he installed a more automated sawdust-burning BCS with a larger capacity.

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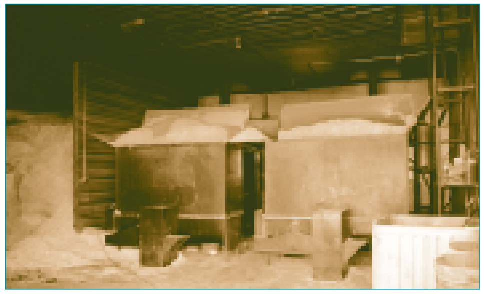
Lea's son, Marc, has now taken over the farm operation and responsibility for the BCS. In 1998 the operation was increased to 700 sows, and the farm heat load increased proportionally. Lea still lives on the farm but devotes most of his time to Maritime Precast Products Ltd., a new enterprise established in 1998. It is housed in a 930-m² (10 000 sq. ft.) concrete fabrication plant adjacent to the farm. The building is currently heated with oil. The Schurmans' BCS heats the sow barn, a large farm workshop and Lea's 185-m² (2000 sq. ft.) home. The system also provides domestic hot water for the home.

Here are the recently filled day bins of the Schurman Farms BCS. The fuel reserve is on the left.



Technical Data

The Schurmans' bioenergy plant now consists of two 160-kW biomass combustion systems. Each system comprises four major components: a 4-m³ fuel (or day) bin; a combustion cell (or chamber); a boiler; and a stack (or chimney).

Each day bin has an agitator – a central rotating shaft with a number of angled paddles. They stir the fuel to prevent bridging and to ensure that it flows continuously to a small, 17-cm (about 7 in.) auger at the bottom of the bin. The auger meters wood chips into the second component of the system, the combustion cell.

The combustion cell has a steel bar grate upon which the fuel (fed by the auger) spreads out, dries and burns. The grate is surrounded by high-temperature firebrick that becomes red hot under heavy firing. A variable speed fan provides two separate streams of preheated primary (or under-fire) and secondary (or over-fire) combustion air to the fire. The combustion cell sends a jet of flame through a firebrick-lined tunnel into the third component of the system, the water tube boiler.

"Our low-cost biomass heat allows us to heat the pig barn more extensively and increase the ventilation rates… the increased temperature and ventilation improves the health of the animals and provides a more comfortable working environment for the staff."

The boiler is a heat exchanger that extracts heat from the hot gases and transfers it to water, which is circulated through the boiler. The cooled gases then pass up the stack, which is the fourth major component in the system.

Hot water from the boiler is distributed to the various heat loads (or zones) in the system via insulated underground piping. The temperature in each zone is regulated by a separate thermostat, which turns the circulation pumps on and off to maintain the desired temperature. The net heat output of the BCS is controlled by an Aquastat – a temperature-control mechanism in the boiler that regulates the quantities of fuel fed to the combustion cell. The BCS operates in either the high-fire mode, when the Aquastat calls for heat, or the hold-fire (or idle) mode, when the boiler reaches the desired temperature.

The burning of fuel in an automated biomass system occurs under ideal conditions – very high temperatures in the cell, with controlled under-fire and over-fire air. This results in high combustion efficiency and low emissions with very little smoke or airborne particulates being produced.

System Cost

The Schurmans' BCS cost roughly $130,000 in 1993. It was installed in an existing building (formerly the farm workshop) because it is located at the centre of the farm. A new, larger workshop was constructed to replace it; part of the $130,000 was spent on the new building and its under-floor heating system.

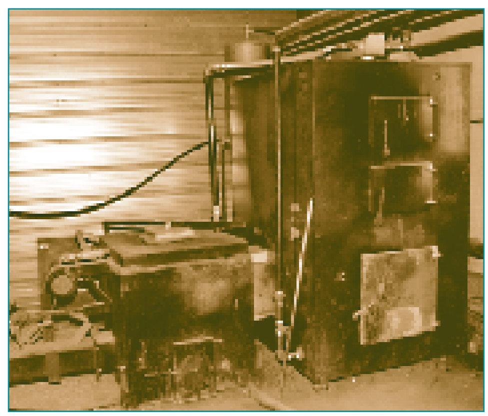
A significant portion of the original capital cost related to the underground piping to the pig barn and the under-floor heat distribution in the building. Much of that cost would have been incurred even if the system had been heated with oil. The incremental cost of the BCS over the cost of an oil-fired heating system for the various buildings was about $70,000. When the sow barn was expanded in 1998, the Schurmans installed water-jacketed lids on the combustion units for roughly $2,500. The manufacturer estimates that these lids increase the peak output of each burner by 20 percent. They also extend the life span of the BCS because the lids and upper refractory are subject to less heat stress.

Biomass Fuel Supply

The Schurmans buy dry chips and green and dry sawdust. They buy green sawdust from Georgetown Timber Ltd., Prince Edward Island's largest sawmill. It is delivered in a 14-m (45 ft.) van equipped with a walking-floor unloading mechanism. This mechanism can push the entire load off in about 10 minutes – without tipping the trailer. The vanload weighs from 25 to 30 t, depending on the moisture content of the sawdust, which can vary from 40 to 50 percent on a wet basis.

Georgetown Timber Ltd. charges $550 per vanload delivered, which is about $22 per t. Over the winter, the Schurmans usually buy eight vanloads of sawdust. During the summer, when only one BCS is operating, they use about three loads of sawdust. This adds up to roughly 300 t of sawdust for the year, at a net cost of about $6,000. (One tonne of green wood fuel at 45-percent moisture content will displace about 215 L of light heating oil. Thus, 300 t of sawdust will displace about 65 000 L of oil.)

In addition, the Schurmans buy about 21 8-t truckloads of dry (15-percent moisture content) waste fuel from a nearby business that makes window frames. At a cost of $75 per load, this totals about 165 t for a net cost of about $1,600. (One tonne of dry wood fuel at 15-percent moisture content will displace about 350 L of heating oil. Therefore, the 165 t of dry fuel will displace about 58 000 L of heating oil.)



Here is one of the two 160-kW BCS on the Schurman farm.

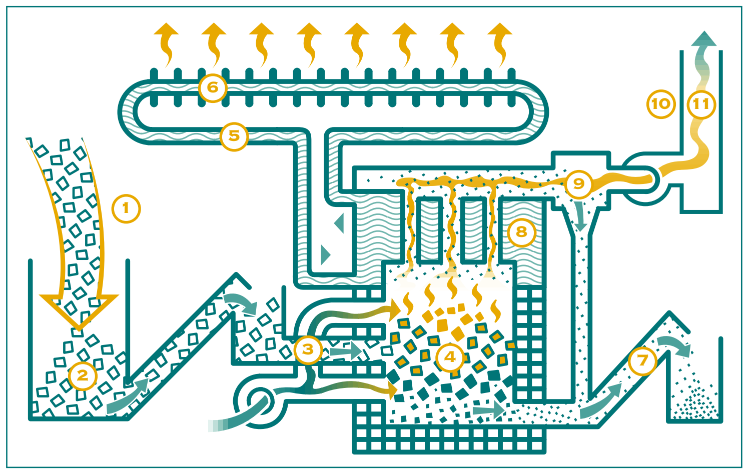
The dry fuel is mixed with the green sawdust to produce a fuel mixture that is suitable for the Schurmans' biomass burners and to boost their peak output. In total, with the mixed fuel, the Schurmans' BCS displaces roughly 123 000 L of heating oil annually.

Mode of Operation and Maintenance

Marc Schurman or one of his employees uses a skid-steer loader with a large bucket to fill the burner's day bins. They usually fill the bins in the morning at around 8 a.m. and top them up at the end of the workday around 5 p.m. They also use the skid-steer loader for many other farm loading tasks.

In addition, they scrape the ash from the grate each day and remove the ash from the burner's ash pan every week. They also clean the fly ash from the boiler every four weeks in the winter (for optimum heat) and every eight weeks in the summer.

Biomass Combustion System – General Layout
1. Fuel Delivery
2. Fuel Storage
3. Automatic Feed
4. Combustor Unit
5. Water Piping
6. Radiators
7. Ash Disposal
8. Heat Exchanger
9. Particulate Removal
10. Stack
11. Exhaust Gases



Operating Period

The Schurmans' BCS runs year-round to provide heat to the sow barn. From May to September, they run only one burner. Once the main heating season arrives, they run both units.

System Performance

The Schurmans are satisfied with the performance of their BCS. Lea Schurman acknowledges that their biomass system does not have quite the convenience of an oil-fired system. "It requires a little more effort to look after it than an oil system," he says, "but it is not so time-consuming that it is not worth the effort, given the savings."

The Schurmans have had to make only minimal repairs to their BCS. Repairs have been made to one controller timer and several feed auger motors. After they had a three-phase power installed in 1998, problems with the auger motors were greatly reduced.

Payback and Annual Savings

Because the Schurmans have operated the farm energy system on bioenergy exclusively, they do not have a practical way to compare what it would cost to heat the system with oil. They know neither the payback period nor their exact annual energy cost savings, although they believe the savings to be substantial.

If their BCS actually displaces about 123 000 L of light oil annually, it would be worth about $55,000 (at oil prices in the summer of 2000 – i.e. 45 cents per litre). Net annual savings are determined by deducting from this amount the cost of biomass fuel purchased (about $7,600) and electricity used by the BCS, as well as repairs and labour. Thus, the annual savings of the Schurmans' BCS should be about $45,000 per year, based on oil prices in 2000.

Principal Benefits to Schurman Farm Ltd.

In Lea Schurman's words, "the savings in heating oil are the main benefits of the biomass system." Marc Schurman refers to better living and working conditions in the pig barns: "Our low-cost biomass heat allows us to heat the pig barn more extensively and increase the ventilation rates," he says. "The increased temperature and ventilation improves the health of the animals and provides a more comfortable working environment for the staff."

Marc likes the under-floor heat for the shop. "It's nice to be able to go into a heated shop with warm floors. If it were heated with oil, you would tend to heat it only when you were using it, and it would be less comfortable," he says. However, he notes one downside to the under-floor heating system: "If you are standing at the workbench for any length of time, the warm floor makes your feet sweat. Then, when you go outside, they get cold. If we were doing it again, it might be better not to put any under-floor heating lines in the floor directly in front of the workbench."

He was also forthright about the cost of a BCS. "A biomass system has a higher capital cost than an oil-fired system, but you get it back over time with lower energy costs," says Marc. "Of course, the federal government grant we received in 1993 helped pay for the system."

Lessons Learned

When Marc Schurman was asked if he would do anything differently if he were building a new biomass system, one thing came immediately to mind. "I would make the fuel storage building larger with taller doors," he says. "With this building, we have just enough room for two vanloads. It would be nice to have some extra space. Because the doors are too low, the vans have to dump the fuel outside, and we then push the sawdust into the building with the tractor. It would be ideal if the vans could back right into the building and push the fuel off inside. That would save us a lot of time."

The burning of fuel in an automated biomass system occurs under ideal conditions – very high temperatures in the cell, with controlled under-fire and over-fire air.

Asked what advice he would offer to some-one thinking about installing a BCS, Marc says, "timing is very important when you are installing a biomass combustion system. You should get it done early, before the bad weather sets in."

A twin-burner BCS, such as that owned by Schurman Farm Ltd., offers many advantages. It allows the burner(s) to be matched to the heat load. For example, as noted above, the Schurmans run one burner in the summer when the heat load is low and run both units during the cold winter months. This matching allows the burners to run in their optimum range, where efficiencies are high and emissions are low. It also allows 100 percent of the peak heat load to be handled by low-cost wood heat. In many cases, an oil backup system is not installed. In addition, if a mechanical failure does occur with one burner, the second unit can carry at least 50 percent of the load until the other one is repaired. This avoids a total loss of heat, as would be the case with a single larger unit.

Future Plans

With the increased heat load in the sow barn, the Schurmans' 320-kW twin BCS is now being pushed to its limit. Lea Schurman would like to heat the concrete plant with bioenergy, and his son would like to connect his 225-m^2 (2400 sq. ft.) home to the system. They are contemplating adding more capacity to their current BCS, but have not yet decided precisely how to do it. One option is to expand the existing building and add another BCS.

The Schurmans are comfortable with their current bioenergy system. Given their experience, the odds are that they will follow through with increasing the capacity of their BCS and using even greater volumes of biomass fuel in the future.

Developing the Canadian Market for BCSs

Natural Resources Canada's (NRCan's) Renewable Energy Deployment Initiative (REDI) promotes investments in renew-able energy technologies through REDI for Business. These include biomass combustion systems that produce space heat and water heat for businesses.

REDI for Business will refund 25 percent of the purchase and installation costs of a qualifying BCS (i.e. one that is high-efficiency with low emissions) for a business, to a maximum of $80,000. The program is in effect until March 2004. REDI serves to stimulate market demand for renewable energy systems and ensure that industry infrastructures are developed to meet consumer demand.

A buyers' guide to small commercial biomass combustion systems is available from NRCan. For more information, contact the following:

Natural Resources Canada
Renewable Energy Deployment Initiative
580 Booth Street, 18th Floor
Ottawa ON K1A 0E4
Tel.: 1 877 722-6600 (toll-free)
Fax: (613) 943-1590
E-mail: redi.penser@nrcan.gc.ca
Web site: http://www.nrcan.gc.ca/redi

Find out more about how you can benefit from biomass combustion systems or other types of renewable energy technologies by visiting NRCan's Canadian Renewable Energy Network (CanREN) Web site at http://www.canren.gc.ca

Glossary

Aquastat – A temperature-control mechanism that maintains the boiler temperature within a preset range by regulating the quantity of fuel fed to the combustion cell and hence the amount of heat produced. When the boiler temperature drops below the low-limit setting, the Aquastat signals the BCS to operate in high-fire mode. In this mode, the combustion air fan runs continuously, and the feed auger delivers large quantities of fuel to the combustion cell at frequent intervals (e.g. 10 out of every 20 seconds). When the boiler temperature rises to the upper-limit setting, the Aquastat signals the BCS to switch to the hold-fire (or idle) mode. In this mode, the combustion air fan is shut off, and the feed auger delivers only small quantities of fuel to the combustion cell at relatively long intervals (e.g. 5 out of every 100 seconds). It provides only enough fuel to maintain the fire.

BCS – An abbreviation for biomass combustion system.

Bridging – Bridging refers to the tendency of some small-particle biomass fuels to lock together in an arch configuration above a fuel feed mechanism (such as a screw auger or a day-bin agitator). When this happens, the fuel above the bridging configuration ceases to flow, the BCS is starved for fuel and the production of heat is curtailed.

Cord – A traditional North American unit for measuring the volume of wood. A cord represents a pile of neatly stacked wood that measures 1.2 m x 1.2 m x 2.4 m (4 ft. x 4 ft. x 8 ft.). The cord's volume, including air spaces, is 3.6 m^3 (128 cu. ft.), but the actual solid wood volume is about 2.3 m^3 (80 cu. ft.). A cord of softwood weighs about 1.6 t. A cord of green softwood (chipped) can displace about 340 L of heating oil.

Moisture content – The moisture content in wood or other biomass fuels is most commonly expressed on a "wet basis." Moisture content on a wet basis (or MCWB) refers to the proportion of the total weight of a given quantity of wood that is actually water. For example, if green wood has a moisture content of 45 percent MCWB, then 45 percent of the total weight is water and 55 percent of the total weight is wood.

Units of measure – Wood chips and other particulate wood-waste materials are sold in a variety of measurement units. Wood fuels may be sold by weight (e.g. by the tonne) either with or without a calculation of the moisture content of the wood. Wood fuels may also be sold by volume (e.g. in cubic metres or cubic yards) or simply by a fixed amount for a truckload of a stated volume. The haul distance from the source (e.g. a sawmill) is also commonly factored into the delivered price of biomass fuels.

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