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

Denco Enterprises
Heating a Greenhouse Operation and Other Integrated Heat Loads

Biomass Combustion Systems
Spring 2001

Denco Enterprises' dry kiln and greenhouse complex. Biomass fuel is stored outside on the right.

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.

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.

Small 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 biomass combustion systems (BCS).

Introduction

Denco Enterprises is a small greenhouse operation in Whites Cove, New Brunswick, near Fredericton. When owner Roger Hyatt got into the bedding plant business in the early 1990s, he looked at various energy options, including oil, propane and wood. (Natural gas was not available in his area.) He concluded that an automated wood-chip system was the most attractive option. A 130-kW BCS was installed in 1992.

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When people think of energy-intensive businesses that could benefit from low-cost bioenergy, greenhouse operations often come to mind. Greenhouses do indeed consume a lot of heat when they are being operated during cold weather. However, many greenhouses are used only to produce bedding plants in the spring. So the operating periods tend to be relatively short, which generally does not favour biomass heating systems. Biomass combustion systems (BCSs) are capital-intensive and provide the best paybacks when a business has a relatively long annual operating period. The ideal situation is a year-round heat load.

Because low-cost biomass energy is available, Denco Enterprises can economically operate its greenhouses for much longer periods than is the norm. And it has integrated its BCS with a number of other heat loads. The company is a successful model for other greenhouse operators.

Technical Data

Roger Hyatt's BCS has four major components: a 2-m^3 fuel (or day) bin; a 130-kW combustion cell (or chamber); a boiler; and a stack (or chimney).

The day bin has an agitator – a central rotating shaft with a number of angled paddles. They stir the fuel to prevent bridging to ensure that it flows continuously to a small, 13-cm (about 5 in.) screw 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 gets red hot under heavy firing. A variable speed fan provides two separate streams of preheated, primary (or underfire) and secondary (or overfire) 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, a water tube boiler.

The boiler is a heat exchanger which 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.

That heat is then distributed to the various heat loads (or zones) on Hyatt's property 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.

Roger Hyatt's 130-kW BCS with the workshop area on the left.

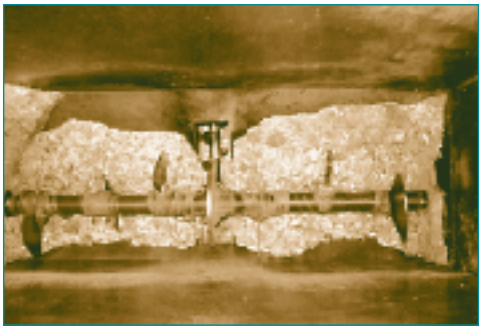
This results in high combustion efficiency and low emissions with very little smoke or airborne particulates being produced.

Hyatt's biomass system heats 1114 m^2 (12 000 sq. ft.) of greenhouse area for bedding plants. It also heats and provides domestic hot water to his home and that of his father; the homes equal roughly 370 m^2 (4000 sq. ft). From April to October, he also heats a 70 000-L, above-ground swimming pool (which is housed in a plastic-covered building).

Biomass Fuel Supply

Roger Hyatt obtains barky wood chips from the nearby sawmill owned by his employer. The chips are mainly produced from cedar and larch slabs, with small amounts of spruce and other species.

The heat distribution system in the greenhouses consists of high-temperature plastic piping. At first, Roger Hyatt ran the piping underneath the benches upon which the flats of bedding plants sit. However, in his newest greenhouse, he installed under-floor heating. Now he places the flats of bedding plants directly on the warm floor. Using this approach, he can reduce the greenhouse temperature by 8°C (15°F) because the heat is directed right at the young plants.



Here is the agitator located in the day bin of Roger Hyatt's BCS.

Roger Hyatt also installed a 7570 L (2000 gal.) storage tank, which he charges during sunny winter days when the demand for heat is low. He draws off this heat reserve during cold nights to balance the supply and demand of heat, and optimize the capacity of his biomass system.

In 1999, Roger added a 27-m^2 (290 sq. ft.) dry kiln to his building complex. During the spring, summer and fall, there is low demand for heat in his greenhouses. So he dries lumber for a nearby sawmill, where he is also an employee. The dry kiln has under-floor heating and currently reaches temperatures of 49°C (120° F). He plans to add additional baseboard radiation to the building so he can raise the temperatures even higher and speed up the drying process.

System Cost

Hyatt's BCS cost roughly $16,000 in 1992. That covered only the burner, the boiler and the stack or chimney. The building housing the BCS is integrated with the greenhouses. The heat distribution system has slowly expanded as the business has developed. A separate, low-cost fuel storage building was added in 1994.

He burns 275 t (about 160 cords) of wood chips per year. Given that Hyatt's wood chips are relatively dry, this volume of wood chips displaces about 75 000 L of heating oil. (One tonne of wood chips at 35-percent moisture content displaces 273 L of heating oil.)

Mode of Operation and Maintenance

Roger Hyatt uses a tractor with a front-end loader to fill the burner day bin. The bin is usually filled only in the morning during spring and fall when the heat demand is moderate. During winter when the energy demand is high, the bin is filled in the morning and at the end of the day.

Roger's low-cost biomass heat gives him options that are not available to other green-house owners.

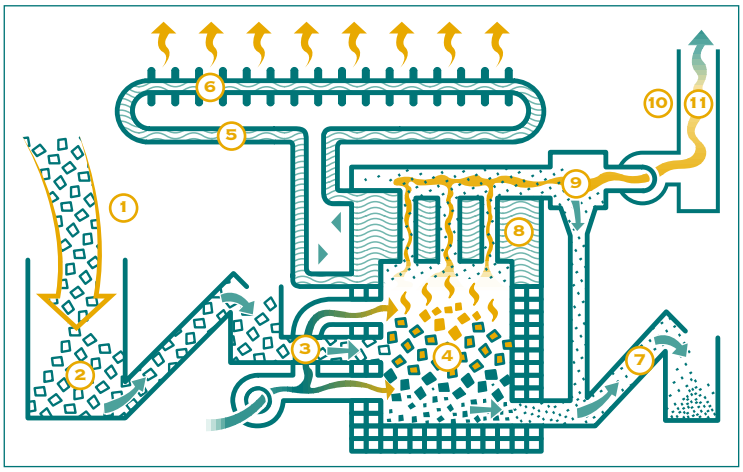
He scrapes the ash from the grate and cleans out the burner ash pan on a daily basis. "With barky chips, there is a fair amount of dirt in the fuel and that

produces quite a bit of ash, so ash has to be removed from the burner every day," says Roger. "I clean the fly ash from the boiler roughly every three weeks for optimum heat in the winter and about every six weeks during the summer."

Roger spends very little additional time on the system. "These biomass burners are pretty low maintenance machines," he says. "I spend about an hour a month doing maintenance."

Operating Period

Besides the greenhouses, Roger Hyatt has added several heat loads, including the two homes, the swimming pool and the dry kiln. They enable him to operate his bioenergy system year-round. (He occasionally shuts the system down for brief periods in the summer if he goes away on vacation or for business.)



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

System Performance

Roger Hyatt is satisfied with the performance of his BCS. He does not find it particularly difficult or onerous to operate. But he acknowledges that having a basic understanding of mechanical systems and a good attitude are important. "You have to understand how the system works and you have to want to make it work, but it's not that hard," says Roger.

In eight years of operating the system, repairs have been minimal. Roger Hyatt has replaced the electric motor on the feed system, a bearing on the agitator in the fuel bin and a broken shaft on the gearbox. He considers this quite reasonable.

Payback and Annual Savings

Roger Hyatt estimates that his BCS paid for itself in three and a half years, starting in 1992. But at today's higher oil prices, he believes that the payback period would be considerably shorter. Roger calculates that wood chips currently cost him about one quarter of the price of heating oil or propane.

Principal Benefits to the Hyatt Business

Roger Hyatt is happy with the amount of money that his biomass system is saving him each year. That is clearly the principal benefit to his business. As well, he believes that, in many respects, wood is preferable to oil. "There is no danger of an oil spill around here, nor is there a nasty smell from the system as there can be from oil-fired systems," says Roger. "Also, my boiler is not pressurized, so no boiler inspectors have to come here. And I don't need boiler insurance. This boiler won't ever explode."

Roger's low-cost biomass heat gives him options that are not available to other greenhouse owners. "I can start my bedding plants much earlier in the season," says Roger. "I also run one greenhouse throughout the winter and over-winter plants for the next year.

I even over-winter plants for other people in the area. The radiant heat from the burner also heats my workshop. It's nice to have a warm place to work."

Lessons Learned

Roger finds that the BCS works best when there is a good load on the system and the combustion cell is running very hot. "When the firebricks are red, heading to white hot – that's where the gasification really takes place and you get your best fire," he says.

When asked if he would do anything differently if he were to build a new biomass system, only one thing came immediately to mind. "I would make the ceiling taller in the furnace room. This one is only 2.4 m [eight feet] high, which is really too low," says Roger. A higher ceiling would be better from a fire safety perspective. And it would be easier to load the day bin with a front-end loader.

Roger finds that the fuel for his BCS burner has an optimum range of moisture content. While most people think that very wet or green fuel would be the main problem, Roger's main concern is about the fuel being too dry. "I find that 35 percent of moisture fuel works best. You need some moisture in it, or you don't get the heat."

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 someone considering installing a BCS, Roger says, "You should compare what the heating costs will be with wood and oil or propane over six to eight years. Biomass combustion systems are capital intensive; however, if you compare the costs over time, they can look very attractive. But if I were putting in a new system, I wouldn't even bother to compare the cost of wood with other fuels. I know that wood is my most economical option." He acknowledges that he has a very favourable situation, with a sawmill producing chips so close. "But I think that there are more good opportunities for bioenergy heating systems out there than people tend to realize," says Roger.

Adding new heat loads, as Roger Hyatt did, is typical of BCS owners. When low-cost energy is available, it is only natural to find new uses for it to shorten the payback of the system and generate more revenue. Roger's underused BCS was a low-cost business opportunity for him and for the owner of the sawmill, who got the services of a dry kiln at little or no capital expense.

Future Plans

Roger Hyatt's 130-kW burner is being pushed to its limits with the various heat loads that he has connected to it. He would like to buy a new burner that is one or two sizes larger, although he is not sure when he'll buy one. He thinks he can keep the same boiler. As things stand today, there is little doubt that Roger Hyatt will be operating his biomass system for many years and continue to seek out new uses for bioenergy.

Developing the Canadian Market for BCSs

Natural Resources Canada's (NRCan's) Renewable Energy Deployment Initiative (REDI) promotes investments in renewable energy technologies. 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 (i.e. high-efficiency with low emissions) BCS 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 the 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 the hold fire 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 high x 1.2 m wide x 2.4 m long (4 ft. x 4 ft. x 8 ft.). The pile 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 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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