On-Farm Energy Case Study
Waste Wood Chips for Greenhouse Heat
Stow Greenhouses - Stow, MA

Fred Green is the owner/operator of Stow Greenhouses in Stow, MA, which has 35,000 sq. ft. of greenhouse space that is used to produce cut lilies for the wholesale market, year-round. The greenhouse must be maintained at 65 degrees F, and additional energy is needed to melt snow off the gutter-connected roof in winter to keep it from blocking sunlight. Prior to converting to a biomass heating system, the operation used 30,000 gallons of heating oil annually.

Asiatic and Oriental lilies are planted and harvested all year long at Stow Greenhouses, for sale to the wholesale cut flower market.

It became clear to Fred that the rising price of heating oil posed a risk to the profitability of his business long before oil prices hit their historic high levels. Back in 2004, when he started investigating alternative heating system options, he got the idea of using waste wood from a nearby nursery operation. The nursery owner was allowing his commercial customers to dump wood chips they collected from their jobs at no charge, so they didn't have to pay to take them to landfills. The nursery would then sell these chips to an electric power plant.

Clearly there was a good supply of waste wood and wood chips in the western suburbs of Boston, but Fred had to decide not only what equipment would be used to burn the wood, but also what was needed to handle it. He visited a dozen different commercial wood burning installations in the eastern U.S. and Canada to get a better understanding of his options. Despite the rigor of his initial research, there was still a lot of trial and error until a satisfactory system was in place.

The first unit that was installed at Stow Greenhouses in 2005 was a 1.5-million-Btu unit from Advanced Recycling Equipment, which was designed to burn sawdust but appeared suited to wood chips as well. The system presented several problems that Fred worked to resolve, before finally deciding to sell it.

This 2 million Btu Advanced Recycling unit that Fred bought for $100,000 proved problematic, since it was really designed to burn sawdust, not waste wood chips. He eventually sold it.

First, the hot-water heat exchanger wasn't big enough, so even at full capacity it was necessary to burn oil as well as wood chips to maintain the greenhouse at the proper temperature in the dead of winter. A larger heat exchanger fixed that problem, but then there were problems with the 45-foot belt conveyor that fed chips into the boiler. The belt wasn't designed for the weight of the chips, and as a result it tore due to the friction between the belt and rollers. Sometimes chips would wedge in between the roller and the belt, causing it to jam. Purchasing a screw auger from a company that sells used saw mill equipment solved that problem. However, the irregular shape of the chips Fred was using – especially longer pieces of branches that made it through the processing stage – caused another problem. These would cause the flow of chips to 'bridge' and create a dam that shut down the supply to the boiler, causing it to shut off. Eventually Fred settled on a rail-type system to deliver the chips into the furnace.

Fred decided to set up a system that would handle the fuel he had. He purchased a used Conifer furnace manufactured by Hern Iron Works (www.hernironworks.com/conifer.html) which makes a range of furnace sizes. Fred got the 3 million Btu model 49-S for about $17,000, and connected it to a Kewanee wood-fired boiler (Kewanee is no longer in business but used models are available, as are new parts at: www.ciciboilers.com/parts_kewanee.htm) and a 3,000 gallon water tank. Buying used components, and then making several modifications to the furnace, like adding a new door for about $1,000 and replacing the internal 'steps' that guide the flow of fuel, Fred was able to set this system up for about $30,000. He also installed up a fan to pull rather than blow air through the furnace, since that does a better job of forcing oxygen through the chips, leading to better gasification. And, he installed a special 'screw' that is used to force chips into the furnace in the event that a bridge forms at the end of the auger.

The 3 million Btu Conifer furnace heats water in the Kewanee boiler; valves are set to control how much of the hot water is sent to heat the greenhouse or stored in the 3,000 gallon reservoir.

Metal rails, bottom left, move chips that are dumped in the bin forward toward the furnace, where a smaller rail system then carries them into the furnace for combustion.

There are challenges with using waste wood versus purchasing a supply of relatively uniform wood chips from a sawmill. You have to be able to deal with branches, stumps, construction debris and other contaminant such as plastic and metal trash that can come with your 'free' fuel supply. Fred's processing system separates out the worst of the contaminants, but he needed a combustion system that could handle irregular-shaped pieces of wood and a small amount of other debris.

Fred holds the type of long wood chip that used to cause 'bridging' on his roller delivery system. Now that he uses metal rails to move chips this is less of a problem.

Keeping the furnace running, and running hot, is important to getting clean combustion and avoiding the small amount of smoke that's created when the furnace is cold and then re-started. At full-bore the temperature inside the furnace is about 2,000 degrees F, which is hot enough to cause near-total combustion and thus a minimum of pollution, including particulates. (Particulates are a big problem with some outdoor wood boilers that do not operate consistently at high temperatures.) When demand for heat is low in the greenhouse, Fred likes to keep the furnace operating at no less than 1,000 degrees in order to avoid any smoke. The problem is – what to do with all that heat?

The 3,000 gallon tank of water is Fred's latest innovation. By connecting it to the boiler and his hot-water heating system, he created a large reservoir for excess heat that is not needed in the greenhouse during the day, but will be needed at night. Fred also uses some of this excess heat to run a large steam sterilizer that treats his coir potting medium so it can be re-used again and again to grow the lilies. Further, to control Botrytis in the greenhouse, Fred has plenty of heat for driving off humidity when necessary. When there's simply too much heat that can't be used, the reservoir simply boils off water that is later replaced. Says Fred: "it's unbelievable that people are paying 4 and 5 dollars a gallon for oil, and we have so much heat we can't get rid of it."

It's true that Fred has a seemingly endless supply of free fuel – but it comes with a price. He's got to process the chips by separating out the trash and grinding before storing the finished material to keep it dry.

He allows landscapers, arborists, phoneline and powerline crews to drop off their wood chips for free, but he doesn't demand that the chips be of any particular quality. "You get all kinds of junk in with the chips – tools, barrels, trash – but we don't look a gift horse in the mouth." The unprocessed chips are bucket-loaded from the designated drop-off area to a nearby location where large objects are removed before they are run through a Sundance Hammermill grinder. Fred got bought this $75,000 unit used for a fraction of that cost on e-Bay. It can re-grind 30-40 yards of chips an hour, and works well with the bucket loader.

Hammermill grinder and poly-covered storage that are used to process and store the wood chips.

For the first 3 years of using waste wood chips as a fuel, Fred didn't bother to grind it, he just used a screen to remove the larger pieces. But that left a lot of unusable material due to its size or shape, and some long but thin pieces of wood would get through the screens and later jam the delivery into the furnace. So now, he grinds everything that will be burned. And if a small amount of plastic debris gets into the chips, it's no big deal, given the high temperature that the furnace operates at.

Dry wood chips generate more Btus per cubic foot than wet chips, and they make less smoke. "We didn't keep the chips dry the first winter, and that was a big mistake" says Fred. He set up a 28x80 wood structure covered with a layer of clear poly to store the chips and keep them dry. It holds 1,200 cubic yards of chips, which is enough to get through the coldest months, but only about half of the 2,500-3,000 yards that will be burned annually. The remainder is stored under plastic tarps. When there's an excess Fred can sell the chips to landscapers.

Moving the chips has also involved a learning curve. "First we had a 30-hpNew Holland with a bucket, but the front axle broke; then we had a 50-hp Kubota, but the pistons on the bucket went and the tires came off the rims, and we finally realized that tractors were not designed for this type of continuous 'front end' work so we bought a 50-hp Cat loader for $38,000 and it has worked well. Burning is easy, boilers are easy – handling all those chips is a challenge."

Vern Grubinger 9-15-08