



Whole-Tree Wood Pellet Boiler System: Townsend School District, Montana

In the late winter of 2007, Townsend School District became the first project as part of the Montana Fuels for Schools and Beyond (FFS&B) program to heat their schools with a wood pellet-fired boiler system. The district was the first to try burning ‘whole-tree’ pellets, which are composed of materials from logging residues that would otherwise have been wasted—destined for piling and burning. The whole-tree pellet system posed some new challenges to the school staff, the pellet manufacturers, and the burner manufacturers. But with school staff enthusiasm and dedication along with diverse and creative funding, and skilled and responsive contractors, architects and engineers, the biomass system integration for Townsend schools is a success.

Background

Townsend School District, located just southeast of Helena, Montana, serves over 730 students in grades K-12. It is one of the lowest-funded districts in the state, and thus is always looking for ways to reduce operating costs. A limited budget notwithstanding, Townsend schools provide high quality education resources for the community including a recycling program and a hands-on work education noxious weed program that includes an on-site insectary where students raise insects as a bio-control for weeds, noxious weed education, weed mapping, and more.

In 2004, when the school district first looked into the prospect of a biomass heating system, the district was spending an average of \$40,000/year to heat 120,000 square feet of campus with fuel oil and propane. At that time, fuel oil prices were \$1.12/gallon and propane was at \$8.74/dkt (\$0.80/gallon). As of April 2008, fuel oil prices for the district have increased to \$3.52/gallon, while propane prices remain the same due to the small size of the publicly-regulated distribution system.

The first engineering assessment for the school district was conducted in 2004 by CTA Architects and Engineers. This assessment evaluated the feasibility of integrating a larger-scale biomass boiler system that would provide heat to not only the school campus but also the neighboring facilities of the county courthouse, new jail, and health center. This initial assessment of integrating multiple facilities into a district-type biomass system didn’t show great potential, but the school conversion alone looked promising. A more in-depth analysis was conducted in 2005, and plans for converting the school campus to biomass heat moved forward. This analysis estimated a project cost of \$425,000 and fuel cost savings in excess of \$1 million over the 30-year life of the system. With that, the school district applied for and was awarded a Fuels for Schools grant to help with the design and construction costs.

Financing the Project

When complete, installation of the pellet heating system totaled \$432,000 and covered design and engineering; the purchase and integration of two 1.1 million BTU/hr output pellet burners; an emissions stack; a storage silo and surrounding fence; a pneumatic ash auger system; asbestos abatement; and piping the campus together. The school district combined a creative portfolio of funding sources including district funds of over \$46,000, the Fuels for Schools construction grant of \$190,080, a \$15,000 grant from the local conservation district, and a \$14,000 grant and \$140,000 low-interest loan from the USDA Rural Development Community Facilities Grant and Loan Program. Furthermore, Townsend School District has received \$12,420 from The Climate Trust by selling over 130 metric tons per year of CO₂ emission offsets expected from replacing their fossil fuel usage over the next 15 years.

Carbon Offsets

Townsend was the first school district in the FFS&B program to participate in the carbon offset program with [The Climate Trust](#), a nonprofit organization out of Portland, Oregon that promotes climate change solutions by providing carbon dioxide offset projects and advancing offset policies. By replacing their fossil fuel usage with wood pellets, the district is expected to offset 138 metric tons of CO₂/year.

Burning wood is considered carbon-neutral because, as trees grow, they pull carbon out of the atmosphere and when they burn, die, or decompose, they release that same amount of carbon. With this, there is no net gain of CO₂ in the atmosphere, and growing plants and trees will continue to cycle that CO₂. Compare this to the burning of fossil fuels like petroleum and natural gas, which release old carbon that has been deep in the earth for millions of years, creating a carbon imbalance in the atmosphere which contributes to global warming.

Additional greenhouse gas reduction benefits from woody biomass utilization for energy include not only displacing the burning of fossil fuels, but also encouraging healthy forest thinning which improves forest health and strengthens its ability to sequester carbon, as well as minimizing polluting emissions associated with open slash pile burning and wildfires.

Wood-Pellet System Installation

Utilizing the plans developed by [CTA Architects and Engineers](#), the construction by Big Sky Plumbing and Heating began in June of 2006. There were five boilers on the campus—three fuel oil boilers in the grade school building and two propane boilers in the high school building. It was determined that the most economical, efficient and feasible way to integrate a biomass boiler system was to modify two of the fuel oil boilers in the grade school boiler room to be dual-fuel—burning wood pellets and/or fuel oil, and to then pipe that system into the existing propane heating system in the high school. One of the fuel oil boilers in the grade school was retained. Modifying the existing boilers provided a more affordable option than replacing the entire system with new pellet burners and also allowed the fuel oil system to remain as a back-up.

The two fuel oil boilers removed from the grade school heating system were shipped to [SolaGen](#), the contracted burner manufacturer, to be modified as dual-fuel boilers. Limited access into the boiler room required removing the boilers through the roof using a crane. As this process began, asbestos was discovered in the boiler room. An abatement program immediately followed, and the biomass boiler installation was back on track within two weeks.

Meanwhile, Big Sky Plumbing and Heating worked on connecting the grade school hot water system with the separate high school hot water system 250 feet across the courtyard. Conduits were run through existing utility corridors and attics, and the courtyard was excavated to pipe the two buildings together. A 60-ton storage silo was installed just outside the boiler room with a simple flexible spring auger system that conveys the pellets through PVC piping into the burners. Over the next few months, electrical work was completed and heat exchangers installed. The modified dual-fuel boilers returned from the burner manufacturers and were installed along with two 1.1 million BTU/hr output pellet burners. Upon installation of the system, SolaGen remained on hand to train the maintenance staff on proper tuning and operation of the system and continues to provide technical support to the school.



Installing the pellet burner.

The pellet-fired heating system was designed to meet 95% of the school's maximum heat demand. This is a common engineering practice for biomass boiler systems because they run most efficiently and cleanly when they are operating at full capacity. Designing this way spares the biomass system from running inefficiently at partial-capacity the majority of the year when heat demand is average. During the few very cold days a year when heat demand is at its peak, additional boilers or heat sources can augment the biomass system to meet the demand.

Despite the delay for asbestos abatement and delayed deliveries of materials, the pellet-fired system was operational in February 2007, nine months after construction began. In March 2007, Townsend schools celebrated their new wood pellet-fired heating system with a ribbon-cutting ceremony that drew a number of dignitaries and project partners including representatives of Montana's congressional delegation; The Climate Trust; the Director of DNRC; the Deputy Director of USFS State and Private Forestry, USDA Rural Development; State Superintendent of Public Instruction; and Headwaters Resource Conservation and Development. The schools began operating the wood pellet system in mid-November 2007.



Ribbon cutting, March 2007.

Operational Experience

Whole-Tree Pellet Fuel Supply and Delivery

The school district chose a pellet-fired system as an option for a few reasons. First, pellet systems often have lower set-up and start-up costs than wood chip systems, and second, the campus had limited space available to store large piles of wood chips, so a contained vertical storage silo for pellets made sense. The bulk density of heat energy (BTUs) packed in wood pellets allows for smaller storage requirements and fewer deliveries as compared to wood chips.

Townsend School District was the first Montana Fuels for Schools project to utilize "whole-tree" pellets composed of all tree material which includes bolewood, bark, branches, and needles. This differs from residential-grade pellets which contain solely bolewood. The Fuels for Schools (FFS) grant to the district requires that they utilize biomass material that consists of at least 50% material from forest management practices (i.e. slash from hazardous fuels thinnings or timber harvests) for a period of two years. This advances a key goal of the FFS program, which is to facilitate and encourage the removal of hazardous forest fuels and assist in the development of viable commercial uses for this otherwise low-no value, wasted wood material.

Manufacturing pellets using raw materials from the whole tree was a first for Eureka Pellet Mills and required some experimentation with different ratios of bolewood to other material. They eventually found a good mix that held the pellet form well and provided good heat with minimal ash production. What they came up with was a mix of 50% material from forest management activities and 50% other wood material (i.e., sawmill residues, wood pallets, clean demolition wood waste, urban trees, etc.)

The district runs their heating system for six months, generally from October to April, and anticipates burning an average of 240 tons of pellets/year. The pellet supplier makes bulk deliveries of 22 tons/truckload, so the schools expect about 10-11 deliveries/year. The pellets are delivered with a live-bottom trailer that transfers the pellets into a large box where a tractor-powered grain auger conveys the pellets to the top of the silo. From here, the pellets are stored until they are augered into the two pellet burners as needed by time-set controls.



Delivery truck unloading pellets into box for take up by grain auger.



PTO-powered grain auger loading pellets into storage silo.



Feed tube dropping pellets into burner.



Pellet burner box.

In 2005, the quoted price for bulk-delivered pellets to the school campus was \$92.50/ton. As of August 2008, their cost for pellets has risen to \$122.00/ton. The school district does not have an annual contract with their pellet supplier and negotiates pricing as needed. As fossil fuel prices and transportation costs rise across the globe, pellet producers are hesitant to risk entering into long-term contracts with fixed pricing for consumers.

Challenges with Ash and Clinkers

As the new pellet-fired heating system began operation, it became evident that the ash removal system was not robust enough to handle the mineral and ash residuals from the combusted whole-tree pellets. The unanticipated over-abundance of clinkers was too much for the auger system to digest and resulted in repeated shearing of auger shafts and damaged gears in the motors, which didn't have ample torque to deal with the hard clinkers.

Clinkers are hard, glass-like clumps that are formed in the combustion chamber when partially combusted ash and mineral components of the biomass fuel fuse together and solidify. These clinkers can cause problems for a system, including over-collection in the combustion chamber, obstruction of proper air flow, and clogging and wear of the ash removal system. Clinker formation is fairly common in solid fuel combustion systems and is something that can be managed for in the design of the burner and fuel bed and/or by adjusting factors such as fuel composition and combustion ratios. Clinkers in the school's biomass system can be attributed to the composition of bark, branches and needles as contained in the whole-tree pellets, which contain higher proportions of minerals (specifically alkali and potassium) than residential-grade pellets.



Large clinker from burner box.

The pellet combustion chamber and automatic ash removal system were originally engineered so that as the pellets burn, the ash drops to the base of the burner, where it is automatically augered out and dropped into a second auger that transports ash to a 20-gallon steel drum that is then emptied by staff occasionally as needed. Instead, the maintenance staff found themselves spending a few hours a day manually digging out clinkers from the burner pot and emptying the ash cans. The whole tree pellets were generating 300-400 gallons of ash and 400 pounds of clinkers a month. Further challenging was the fact that access to the burners was down a short flight of narrow stairs, so maintenance staff had to hand-carry full 20-gallon steel drums up the stairs to dispose the material. It became apparent that the system wasn't designed to handle these high mineral fuel and ash loads, and adjustments would need to be made.



Clinkers collecting in burn pot.

First, a simple screen was installed under the burner pot to catch clinkers before they drop into the augers at the base of the fireboxes, but which still allows ash to fall through. Second, the ash auger systems on both burners were revamped with larger gear motors and high quality gearboxes that are better able to digest the ash and clinkers. In addition to making the automatic ash auger system more robust, SolaGen designed and installed a pneumatic ash removal system. With this, ash drops into tubes at the base of the burners and is automatically vacuumed outside of the boiler building into a 55-gallon drum which is emptied once a month. The ash and clinkers are then disposed of at the local landfill.



Screen installed to catch clinkers.

While these upgrades were being made, a study was implemented to determine to what extent the elemental composition of the whole-tree pellets may have been contributing to the high ash and clinker generation. Samples of the whole-tree pellets and resulting ash and clinkers were sent for lab analysis to the Hazen Research Lab in Colorado. Results showed the whole-tree pellets to have an ash content of 4%. For comparison, residential-grade pellets have about 2% ash content, and premium pellets are 0.5-1% ash. Thus the 4% ash content of the school's whole-tree pellets ranges 2-8 times higher than that of residential-grade or premium pellets.



Ash removal drums.

The school district burned through this first load of whole-tree pellets, then ordered a delivery of higher-grade pellets. While still producing ash and clinkers, the amounts generated by the higher-grade pellets are much more manageable and produce expected averages of 55 gallons of ash and 12-20 pounds of clinkers a month. The pneumatic ash removal system is operating well and also helps to reduce time spent on maintenance and daily operation.

In the first season of operating the wood pellet system, the school boiler operator reports spending an average of 40 hours per month on operation and repairs to the system. Outside of that initial time spent on repairs, operation and maintenance of the wood pellet system is fairly easy. Routine maintenance for the boiler operator entails daily checkups of the system temperature, pressure and auger system for a few minutes a few times a day, cleaning clinkers out of the burner pot once a week with a scraper and tongs, and hauling the 55-gallon drums of ash and clinkers to the landfill once a month.

“The issues and set backs in the beginning took time to work through. Although at times stressful and time consuming, my attitude through it all remained positive...I can foresee this system will work well for us in the upcoming years as non-renewable energy costs continue to rise. When everything is running smoothly the systems operation is straightforward and time demands are minimal. Now when problems do arise they are fairly easy to troubleshoot and resolve.”

Jim Riddle, Maintenance Supervisor

In hindsight, it's possible that these ash removal and clinker issues could have been managed for and potentially prevented had there been better communication from the architects and engineers to the burner manufacturers regarding the schools' intent to use whole-tree pellets. The boiler manufacturer was unaware that the system would be burning whole-tree pellets, which contain more minerals and ash, instead of higher grade pellets with less ash production. Had they known this, they might have designed and built the system to handle the higher mineral content and ash load at the get-go.

Fuel Use and Cost

It was anticipated that the school district could see savings of \$25,000 in heating costs in their first year. However, with unforeseen project costs in conjunction with late-season start-up, system down time, repairs and upgrades, and higher fuel oil prices, those first-year savings were not realized. Instead, the

school district's total heating bill increased by \$9,330 over FY 2006-07. Due to delays and various shutdowns, fossil fuel usage was greater than expected, with the school using only 93 tons of pellets in that first year instead of the anticipated usage of 236 tons/year.

"The project was expected to offset 95% of 20,773 gallons of propane and 95% of 14,000 gallons of fuel oil. During the first year of operation propane consumption dropped by 7,967 gallons (38% decrease). Fuel oil consumption dropped by 6,223 gallons (45% decrease), but the price of fuel oil increased from \$2.09/gallon to \$3.01/gallon. The cost of wood pellets has averaged \$122.00/ton. The total heating bill for the School District increased \$9,330 over FY 2006-07. As the wood pellet boilers are utilized more frequently the fossil fuel use is projected to decrease substantially."

CTA Architects and Engineers, April 2008

Conclusion

Winter 2008-2009 will be the second heating season for Townsend schools using wood pellets. School administrators and maintenance staff are confident that the issues faced in the first year have been resolved and are optimistic about the coming years. The school gives great credit to SolaGen, the burner manufacturer, who has been and continues to be very helpful and responsive.

"I feel this project is a positive step for our district. [R]educed facility costs will help us keep educational funding focused on our students and our future . . . This is also an educational tool we can use within the district to teach conservation and stewardship to the staff, students and community . . . With energy costs now affecting everyone, I have noticed a shift in the staff's attitudes toward renewable energy. They have become personally aware of how non-renewable energy costs are affecting their own budgets and I think they better understand our forward thinking with regards to this project and the district budget."

Brian Patrick, School Superintendent

Mr. Patrick, Townsend's School Superintendent and President of the School Administrators of Montana, is spearheading *Repowering Montana Schools*, an efficiency and renewable energy initiative for Montana public schools. Multiple state agencies, organizations and legislators are working together on this school energy initiative, including organizing an Energy Summit for school administrators, compiling informational and financial resources, and seeking legislative opportunities to bring greater energy efficiency options to Montana schools.