**Red School House Biomass Pellet Boiler Project Report**

**Executive Summary:**

This project involved the installation of a biomass pellet boiler at Vermont Technical College and the use of grass for heating fuel. The objectives included installation of the biomass heating system, cultivation of various grass species, pelletization of the grass using a mobile on-farm processing system, and measurements of pellet properties and of the combustion efficiency and particulate emissions. The majority of the objectives were achieved. A Frohling biomass pellet boiler system was installed and currently provides heat for the Red School House building at the Randolph Center campus. This reduced annual heating oil use by approximately 3200 gallons and saved the college $4200 in the first year. Various grass species were cultivated and processed using a trailer-mounted pelletizing system. Pellet processing studies were done to correlate process parameters with pellet properties and establish methods for producing larger batches. A combustion monitoring system was designed and tested. Work is on-going to install the instruments on to the boiler system and to complete combustion studies that measure efficiency and particulate emissions. The equipment and technical knowledge gained from this project is been incorporated into college course curriculum and is presented at public workshop.

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**Consortium/Team:**

Vermont Technical College: John Kidder, Sosten Lungu, Joan Richmond-Hall, Chris Dutton University of Vermont Extension: Sid Bosworth

Biomass Energy Resource Center: Adam Sherman, Kamalesh Doshi, and Deborah Barney

**Project Goals & Objectives:**

A primary objective of this project was to install a biomass pellet boiler system on the Vermont Technical College campus with the goals of reducing heating oil use. A Frohling biomass boiler was successfully installed in the basement of the Red School House Building which houses classrooms and offices for the agriculture program. The system currently provides the majority of heat for the building and this reduced annual heating oil use by approximately 3200 gallons and savings of approximately $4200.

A second objective was to cultivate grass species on the college land, process this feedstock into pellets, and study the pellet properties and combustion characteristics. This work was done through a collaboration between faculty at Vermont Tech and UVM Extension. Various grass species where grown and harvested from test plots in Randolph Center. Some of this grass was processed into pellets using the on-campus mobile pelletizer system. The pellets were tested for heat content, durability and other properties.

A third objective was to complete combustion tests using instruments on the pellet boiler to measure combustion efficiency and particulate emissions. The installed pellet boiler has a limited length of flue duct and installation of combustion monitoring instrument proved to be more challenging than first expected. A system was designed that includes a gas analyzer and filter-based particulate collection to measure burn efficiency and particulate emissions. The components were procured and have been tested. Work is on-going to install the instruments on to the boiler system and to complete combustion studies.

**Final Project Summary:**

The primary objective of the project was to install a biomass pellet boiler on the Randolph Center campus of Vermont Technical College. The system was selected with consulting support by personnel at the Biomass Energy Resource Center and was installed in the Red School House building by Sunwood Energy Systems (Waitsfield, VT). A portion of the matching support was used to complete weatherization work on the building and to install a new stainless steel liner in the chimney. A large pellet bin was installed as part of the project and pellets are delivered in bulk. A separate bag bin is also included to allow combustion of test batches of grass and wood pellets. The system currently provides heat for the Red School House building and during this first year this reduced heating oil use by approximately 3200 gallons resulting in financial savings of approximately $4200. The system in installed in a space that includes room to host public visits, college course lab sessions, and workshop activities.

A second component of the project involved the cultivation of various grass species to process and test as heating fuel. This work was done in collaboration between faculty at Vermont Technical College and the University of Vermont Extension. Test plots of various grass species were cultivated for studies and some of these processed for use as pelletizing feedstock. A round bale chopper was procured for processing the grass bales into feedstock for pelletizing. As described in the next paragraph, some of the grass was successfully processed into pellets as part of an initial research effort. Knowledge gained from those studies will be used to process larger batches for future combustion tests as part of an initial research effort. Knowledge gained from those studies will be used to process larger batches for future combustion tests.

A third component of the project involved the implementation of a pellet processing system to convert the grass and other biomass feedstock to pellet form. To meet the objective of demonstrating an on-farm energy production process we chose to purchase a pelletizing system that could be powered by a tractor PTO and located on a trailer for mobility. The system was obtained from Buskirk Engineering in (Ossian, IN) and located at the college farm. During the summer of 2012 a group of students, working in the Summer of Applied Research Program, completed initial set-up and operated the system to successfully produce wood and grass pellets. This research studied the effect of die temperature, rotation rate, feedstock properties, and other parameters on pellet processing and properties and established baseline knowledge about operating procedures and feedstock conditions which will be applied to produce larger pellet batches.

A fourth task under this project was to establish and utilize methods for measuring biomass pellet properties. To accomplish this two pieces of equipment, a durability tester and a sample splitter, were designed and fabricated by students in the Mechanical Engineering Technology program. Pellet durability is an important property and reflects the ability for a pellet fuel to be transferred using mechanical auger or pneumatic systems without breaking down. As a capstone design project two students designed and constructed a durability tester based on standards established by the Pellet Fuels Institute. This system is used to characterize the properties of pellets produced in the pelletizing system and is also utilized in college courses with lab activities in biomass energy. Another team of students designed and fabricated a sample splitter which is a device used to divide aggregate materials (pellets) into samples of equal size and mass distributions. This equipment is used in current work and is housed in a space adjacent to the pellet boiler in the Red School House building.

To study the combustion of the grass biofuels the project planned for the installation of instruments to measure efficiency and particulate emissions. The first step in this work was to select the proper components and system design. This work was done with the voluntary assistance of a local combustion expert, Mark Champion, and involved a group of three Electromechanical Engineering Technology students who completed the initial design as a senior capstone project. Combustion analysis requires monitoring the gas chemistry and collecting particulates using probes into the flue duct over long burn periods (hours) where gas flow through the flue and through the probes must remain proportional. In a test laboratory environment large dilution stacks can be used. These measurements are more challenging when done in a “real system” where the is less room for ducting and the boiler controls constantly adjusts the exhaust flow. A system design was completed and the major components (gas analyzer, pressure sensors, etc.) and other parts were procured and tested. Diagrams of the system design and other information is presented on a college website. Work on the combustion analysis system continues and during the 2013 spring semester two students will complete design of the flow sensing and control system and the user interface with plans to install and test the complete system on to the pellet boiler in April 2013.

A final and underlying objective was to incorporate the technology and methods developed in this project into educational programs and activities with the goal of continuing forward with training and research that develops knowledge of biomass as a fuel for heating. This goal was achieved through the development of learning activities that are used in the college courses and during workshops and field days.

**Significant Products or Results:**

Information about the project is presented on a website (https://sites.google.com/site/vermonttechre) including information about the pellet boiler system, reports summarizing the pelletizing research, and design information about the combustion systems and other equipment that was developed under this project.