On-Farm Utilization of Biofuel Crops and Bedding Byproducts for Wintertime Heating at Broiler Chicken Grow-out Farms

PROJECT SUMMARY. In 2012, the University of Tennessee Extension received a Natural Resources Conservation Service (NRCS) Conservation Innovation Grant to build and test a centralized, on-farm, biomass fueled hydronic heating system on a broiler farm. This demonstration was conducted because of the increasing and volatile costs for propane, the most commonly used broiler farm heating fuel (**Figure 1**). Heating fuel has historically been the largest expense for broiler farmers (30-46% of yearly cash expenses).

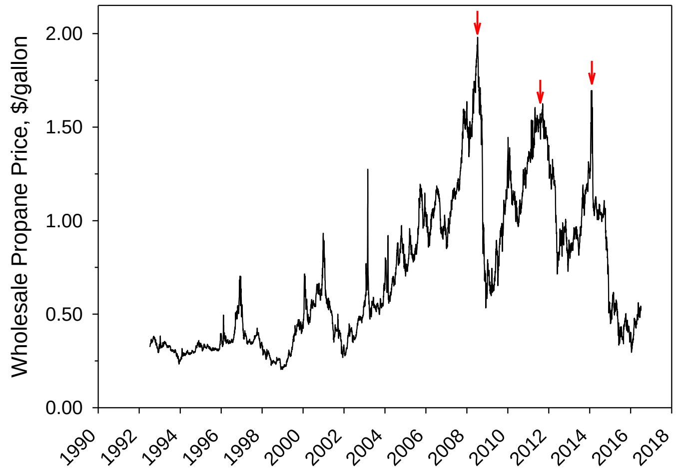

Figure 1. Historical propane prices. Note volatility between 2002 and 2014; prices spikes are noted in 2007, 2012, and 2014.

We successfully designed, specified, and assembled a centralized 100+ boiler horsepower (BHP) hot water boiler/heat distribution system on a cooperating eight house broiler farm in Bradley County, TN (**Figure 2**). A 30×50 ft building was constructed around the assembled boiler (**Figure 2-B, Figure 3-D**). Biomass fuel was supplied via conveyor from an adjacent fuel storage building that contained a day fuel surge bin (**Figure 3-A,D**). The particular boiler chosen had a chain type grate, which allowed the use of inexpensive but often high ashing biomass fuels, two of which were tested successfully during startup (switchgass pellets and green wood chippings from the local county government) (**Figure 4**). The best performing fuel was clearly inexpensive ($\$5/yd^3$) and locally available kiln dried furniture wastes (**Figure 4** - mainly shavings, which are often used for broiler house bedding). Startup occurred beginning 12/3/2014. The boiler was successful used to provide heat to the test farm during January and February, 2015.

In addition to the centralized hydronic boiler, this project successfully demonstrated a method for distributing hot water from the boiler to the broiler houses for space heating. All underground piping between the boiler building and the broiler houses consisted of large dimeter (2-4”) pre-insulated PEX pipe (**Figure 5-A,B**). PEX piping transitioned to uninsulated schedule 10 steel groove lock pipe (2”) within the broiler houses (**Figure 5-D**). Each broiler house contained five hydronic heat exchangers (**Figure 5-C**) sized at approximately 200,000 BTU/hr, three in the brood ½ end of the production houses and two in the grow ½ end of the house. The heat exchangers were placed within five existing heating zones, which allowed the poultry house controller to maintain the temperature setpoint by simply turning the heat exchanger pumps and fans on and off, with second stage heat from the existing propane fired brooders on the test farm.

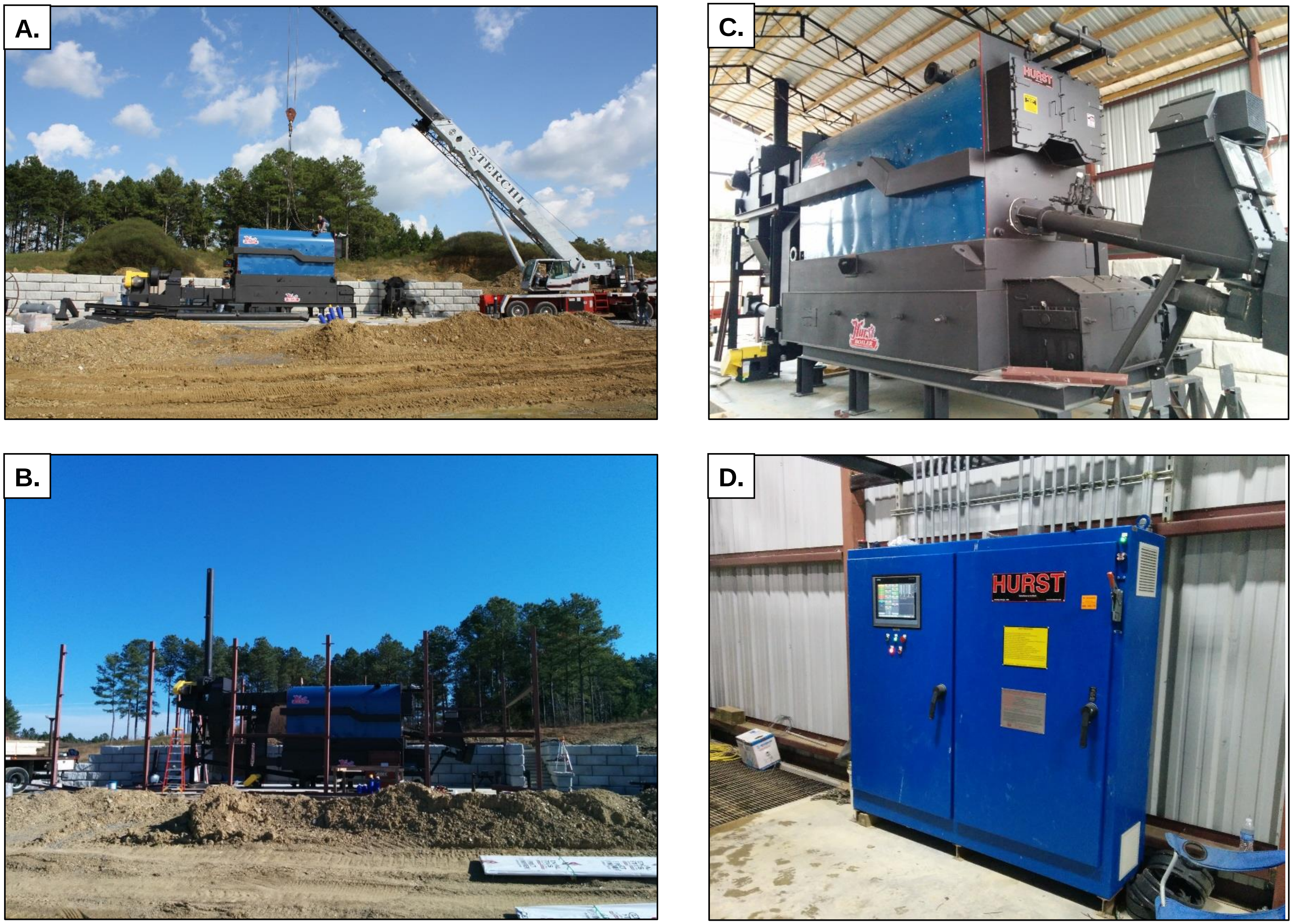

Figure 2. Assembly of 100 BHP hydronic boiler at the cooperating test farm: (A) Crane sitting boiler top; (B) 30×50 ft building being constructed around boiler; (C) assembled boiler close-up; (D) boiler control panel.

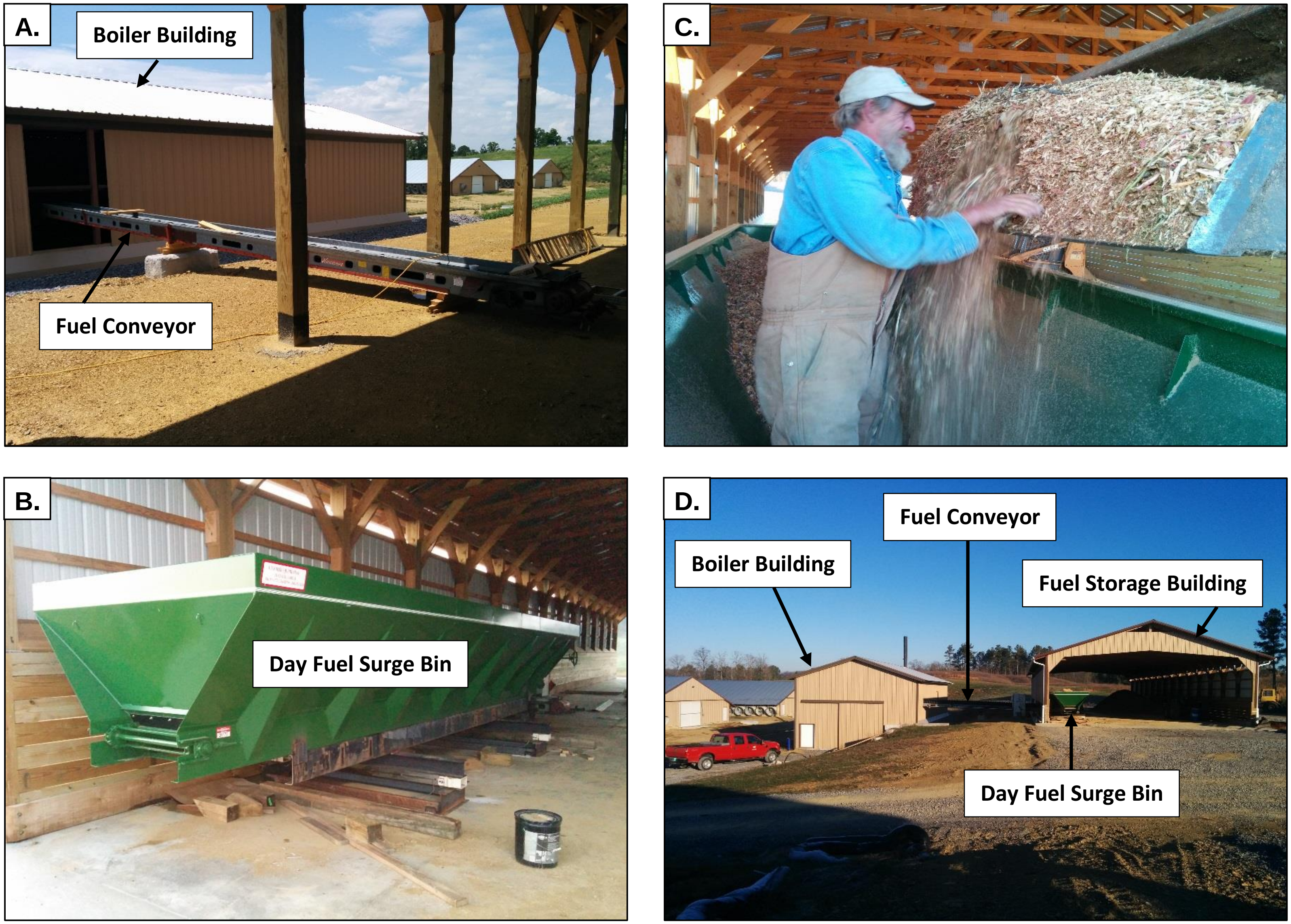

Figure 3. Photographs documenting the fuel storage and conveyance system on the test farm: (A) Fuel conveyor to boiler building; (C) fuel storage building-day fuel surge bin; (C) loading fuel; (D) layout.

Figure 4. Biomass fuels utilized at the demonstration farm.

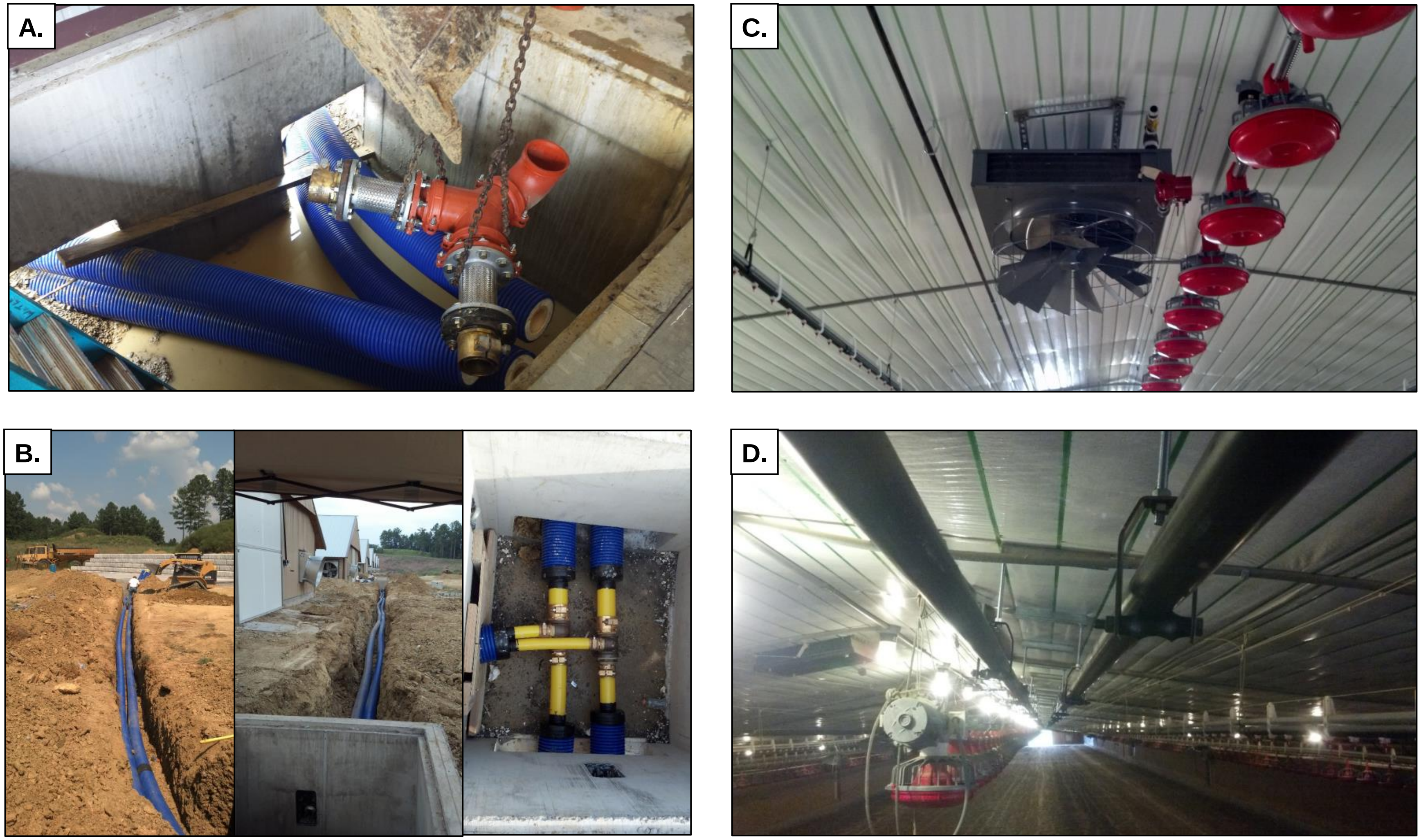

Figure 5. Distribution piping and heat exchanger system for the 100 BHP hydronic boiler at the cooperating test farm: (A) assembling the supply and return distribution piping for production houses 1-4 (right) and 5-8 (left) within the boiler building vault; (B) large diameter pre-insulated PEX hot water supply and cool water return lines from the boiler building (left), between the poultry houses (center), and branch points into the production houses (right); (C) hot water fan coils; (D) 2” schedule 10 hot water supply and return lines within production houses.

RESULTS. Preliminary testing during mid-winter 2015 indicated that the demonstration hydronic heating system, sized at approximately 3.5 million BTUs/hr) could supply at least 85% of the heating needs for eight 55x500 ft broiler houses. The variance from the temperature setpoint was less than 2°F, at which point the secondary heating system (propane brooders) was used. While the system was operated, biomass fuels that were freely obtained (e.g. green wood chips) were used successfully to heat the poultry houses, however boiler operation with high ashing fuels demanded an unexpectedly large labor commitment (2-4 hours per day including fuel provision). Without considering the labor commitment for operation, which may decline with regular use of the boiler, the installed price for the demonstration project, approximately $400,000, enables an evaluation of a return on investment at different commercial propane prices. Propane fuel consumption varies from year to year at the demonstration farm, but averages approximately 5,000 gallons per house (solid sidewall, 55 ft x 500 ft). A reasonable straight cost payback period (<5 years) can only be realized if propane costs exceed $2/gallon, though the installation costs of a hydronic heating system could somewhat defrayed if the production houses were constructed without propane or natural gas fired heating units. **The take-home message of this demonstration project is that hydronic heating systems can be used to successfully heat broiler houses with heating performance similar to in-house brooders, but current commercial propane costs ($1/gallon) are far below the costs necessary to justify investment in a centralized, biomass fired hydronic heating system.**

FUTURE WORK. A precipitous decline in propane costs occurred between February 2014, when the wholesale price of propane peaked at $1.695/gallon, and December 2015 when the wholesale price fell below $0.50/gallon. In January 2016, the wholesale price of propane bottomed out at $0.296/gallon (an 83% decline from February, 2014) (**Figure 1**). For reference, wholesale propane prices below $0.30/gallon last occurred during February 2002, and have only occurred three times in the last 25 years (**Figure 1**). Fortunately for the cooperating farm, the producer locked in a very low propane price during this time period of only 0.$72/gallon.

Such a precipitous decline in propane cost limited testing of the boiler to only the startup period during the Spring of 2015 because tight labor resources could not be made available to operate the boiler given the meager propane fuel savings. Future work is required to define in detail the system heating performance as well as labor and maintenance requirements. The system will remain available and further testing will be conducted if and when propane prices increase above a commercial rate of $1.50/gallon.