By Jeff Pitcairn

Biofuel to the rescue

Engineering genius meets down-home wisdom on Pennsylvania farm.

The advanced hydronic biofuel heating system conditions two 500-ft. chicken houses. Each building contains up to 30,000 birds, which grow from peep to slaughter weight in roughly six weeks.

Leave it to a simple but big-dreaming farmer in Lancaster County, Pa., to help create a shift in the agricultural and heating industries.

You want sustainable? Chicken farmer **Earl Ray Zimmerman** will give you sustainability, but you'll have to climb a mountain of nutrient-rich debris to get it. That was the genesis of the 2012 project at Zimmerman's chicken farm.

In Pennsylvania, poultry is the state's biggest business and that means giant piles of bird waste. Typically, farmers truck it to fields, but that creates a lot of work and surface runoff. While Zimmerman was exploring his options, a local energy solutions company was putting the pieces together for a heating system plan that would take the need for heat and the need to dispose of manure and cancel both out.

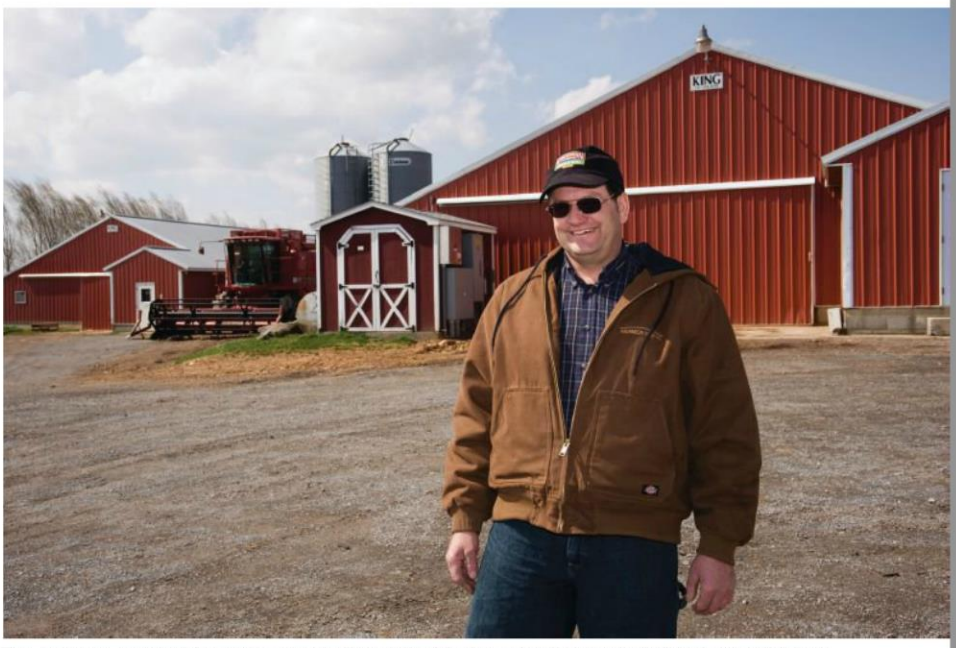
Today, Zimmerman is quick to smile and eagerly talks about the heating system that materialized from that plan. Last winter his two 500-ft.-long chicken houses were heated with a state-of-the-art bio-fueled hydronic system retrofit.

The long, low poultry houses each are equipped to organically raise 30,000 broilers (chickens for meat) from peeps to slaughter weight in only five to seven weeks. The breed of chicken specifically is selected for maximum growth in minimal time. Such rapid growth requires an exorbitant amount of chicken feed. And what goes in must come out. Therein was the first of numerous challenges solved by the Zimmerman's manure-fired hydronic retrofit.

Everybody wins

"Chicken manure (or litter as it's known in the agriculture sector) is a relatively low-energy solid-state fuel," states **Matt Aungst**, co-owner of Willow Street, Pa.-based Total Energy Solutions, the company that designed the heating system.

Photos by John Herr/John Herr Photography



The manure-burning heating system fits well with the overall sustainability theme chicken farmer Earl Ray Zimmerman has applied to his organic Pennsylvania farm.

"You're looking at roughly 3,500 Btu per pound compared to coal that has a gross heating value of 13,000 Btu per pound. Unlike coal, there's a never-ending supply of chicken 'fuel' at the Zimmerman farm. If there's a call for heat, there will always be litter. We've taken the needs of the modern poultry farmer, combined with biofuel combustion technology and, with this installation, dramatically multiplied the benefits by perfecting the heat distribution via custom controls and fan-coil technology not yet seen in the U.S. poultry industry."

The end result can be seen in significant cost reduction and production increases for the farmer, energy independence, reduction of water-source pollution, health and living condition improvement for the animals and more.

On the Zimmerman project, TES, founded in 2004 by Aungst and co-owner **John Albright**, teamed up with Myerson, Pa.-based Farmer Boy Ag Supply and manufacturer Taco. Farmer Boy Ag Supply was the general contractor on the project.

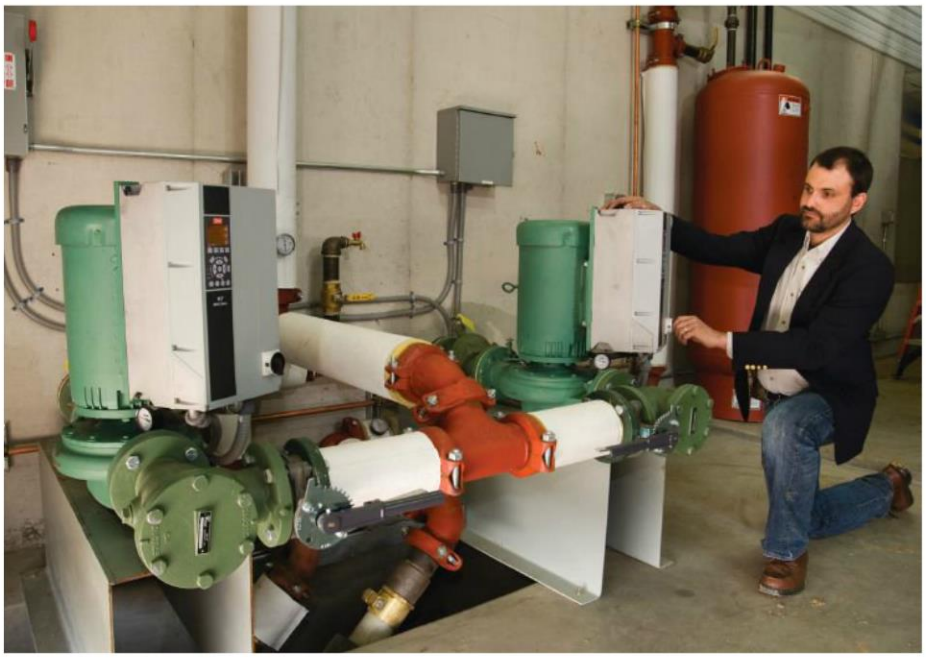
Depending on the outdoor temperature and the age of the birds, one house can call for up to 600 MBH at any given time, but an average heat load in the winter likely is to be 200 to 300 MBH per house. The hydronic system is centered around a 1.5 million Btu boiler. The system was designed and engineered by TES to provide 100% of the heat load at any given time of the year.

One of the most obvious benefits of a litter-burning boiler is that the fuel *needs* to be disposed of. But if you ask Zimmerman, getting rid of litter was the least of his needs.

Sustainable heat

When a flock of birds "goes out" every six weeks, Zimmerman uses a skid-loader to clean all the litter out of the chicken house, storing it until it's needed. At that point, he dumps the dry material into a hopper near the mechanical shed.

The system's Blue Flame Stoker boiler is the size of a service van and occupies its own remote building erected several hundred feet from the chicken houses. An auger feeds dry manure from the hopper into the boiler, while another auger removes the ash remnant from the bottom of the firebox. The boiler doesn't produce strong odors or much smoke. While some emissions are released during the process, the effect is negligible when compared to the potential runoff and water pollution had the manure been spread on fields.



Matt Aungst, who designed the distribution portion of the project, tests redundancy of the system's two pumps. Pump A runs as "duty," leaving Pump B for backup. After 84 hours of runtime, the pumps automatically switch roles.

The heart of the distribution system resides in the mechanical building. Unlike residential hydronic systems with pipes going in many directions and manifolds full of zone valves, the near-boiler piping appears minimalistic. Two redundant green pumps and their VFD counterparts sit side-by-side plumbed in parallel. Pre-insulated Logstor PEX water lines (3-in. diameter) disappear underground through a hole in the clean concrete floor. From there, they run 300 ft. to a distribution manifold between the two chicken houses.

Suspended 10 ft. above, a Taco air and dirt separator keeps the water lines clean and quiet. On the slab, a 125-gal. Taco expansion tank smoothes out the loop. No antifreeze is used or needed.

Aungst, who lauds Bensalem, Pa.-based manufacturers rep firm B.J. Terroni (the 2011 **pme** Manufacturers Rep of the Year) for its help with the project, used Taco's free hydronics systems solutions software to design every facet of Zimmerman's distribution system. "The software allows engineers to calculate loads, size equipment and compare different systems," he says.

High-tech down on the farm

The new Taco SKV3009 SelfSensing pumps each include a motor-mounted variable-frequency drive to deliver the precise amount of flow and pressure needed for the two chicken houses. The pumps accurately respond to changes in system demand without the need for pressure sensors. If Aungst closes a main supply valve to one of the houses, the pump senses the change and ramps down according to the lower demand. Seconds later, the pressure gauge on the supply side starts to drop.

Inside each chicken house, eight CUBO unit heaters hang from the ceiling, providing the water-to-air heat exchange. The units are exclusively designed for the poultry industry and provide air mixing, destratification and lateral heat distribution in a full 360°.

Each of these unique unit heaters has its own Danfoss pressure-independent control valve. The PICVs act as variable-zone valves with the ability to modulate flow as opposed to simply opening or closing. These will automatically function depending on the temperature at the nearest thermistor, or Zimmerman can operate each manually via any Web-enabled device. The valves, like the rest the controls system, are low-voltage, reducing installation cost.

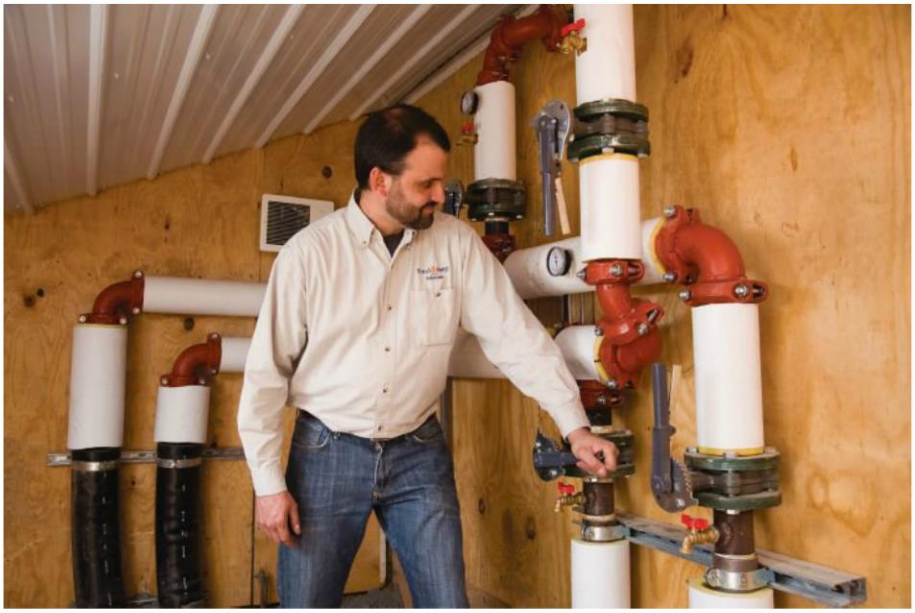
Biofuel to the rescue

However, the PICVs need a compatible circulation system. The pumps react to the specific call for water, regardless of the number of valves calling or how far open the valves are. The modulation of the valves provides a more consistent load on the pumps and the boiler when compared to valves that are simply open or closed. This is especially important for a biofuel system.

"Before the pumps were shipped, the VFDs were programmed in our Cranston, R.I., factory according to data collected for specific flow rates, head pressures and system characteristics," explains Taco Senior Product Manager **Eugene Fina**, who was involved with the design of the inline pump portion of distribution system.

Aungst adds: "A specific program enables the pumps to 'know' exactly what speed to run at any given time. You get tremendous energy savings this way." When in design phase, Aungst calculated for a Delta-T of 25° F.

The system is equipped with a color touch-screen control unit designed, engineered and programmed by TES. This unit automatically controls each zone independently via proportional-integral-derivative control loops and is connected via Ethernet to enable Zimmerman to remotely monitor his houses.



Aungst stands in a manifold room between the two chicken houses. There are no secondary pumps or pressure sensors anywhere in the system. The pumps in the mechanical room sense even the most minute pressure changes anywhere in the system.

Accuracy is paramount

The 7.5-hp pumps each are programmed to supply a maximum of 125 gpm at 85 ft. of head. Pump A runs as "duty," leaving Pump B for backup, Fina says. After 84 hours of runtime (roughly half a week), the pumps automatically switch roles.

To cut down on space and clutter in the mechanical room, the distribution piping incorporates Taco's Plus Two multipurpose valves, which combine all the valve functions normally required on the discharge side of a centrifugal pump into a single unit. This includes shutoff, check, balancing and flow-metering valves.

Zimmerman notes chickens are extremely temperature sensitive. In a chicken house, even a 10° drop for an hour could seriously affect his bottom line. Temperature fluctuation would affect feeding habits for the day. If birds stop eating, they stop growing. If 30,000 birds lose even one day of growth on a six-week schedule, it could mean thousands of dollars in losses.

By design, the CUBO units hang down the center of each house to draw air from the ceiling level, passing it through a water-to-air coil where it's ejected at an adjustable height close to the floor. As the birds grow, the units are raised to supply heat at the optimal level for bird growth.

The hydronic system serving Zimmerman's chicken houses is so accurate that the eight thermistors spread evenly across each 22,500-sq.-ft. house all read within 1° of each other. Having the ability to tightly control the house climate allows Zimmerman to increase what farmers call the "feed conversion," a calculation of how efficiently a bird converts feed into meat.

Since Zimmerman gets paid by the pound of bird, the ability to raise his feed conversion is by far the largest benefit he sees from retrofitting his facilities. Although the boiler eliminates fuel costs, without the ability for the pumps to deliver the precise amount of water needed, Zimmerman wouldn't be much better off than he was with his original heating system. Temperature control in a chicken house is of utmost importance.

But the advantages of an accurate hydronic system don't end there for chicken farmers. Typically, chicken houses are heated by direct gas-fired units. Direct combustion inside the house uses oxygen and produces substantial humidity, both of which force the farmer to run ventilation fans for the health of the birds — even in the dead of winter.

Fan motors can use a lot of energy, but more importantly the ventilation process greatly raises the heat load. A dryer house also means lower ammonia levels, a byproduct of manure, heat and moisture. "It's just one more benefit to the mountain of advantages we've found on this job," Aungst says.

Other green features include the use of a 72kW solar photovoltaic array (panels by Schott Solar) on one of the chicken house roofs. Zimmerman has protected a nearby stream from runoff by growing a riparian buffer zone. Recently, he replaced his CFL lights (nearly 100 per house) with high-efficiency LED bulbs.

At a time when food prices are rising nationally, smarter agriculture systems have the ability to produce more food, with less cost and lower environmental impact. That's smart farming. pme

Jeff Pitcairn has been the Eastern commercial regional manager for Taco for 10 years and in the HVAC industry for more than 25 years working as national sales manager, product manager and sales engineer for leading hydronic equipment manufacturers.