Protein and Power: Turkey's Chicken Gambit

Turkey's largest integrated egg producer, Güres Group, is working with Italian turbogenerator firm Turboden to convert 500 tons a day of chicken manure from 4 million laying hens into green power for the grid.

By Ron Kotrba | November 01, 2017

The need for ever-growing sources of protein and power go hand-in-hand in mankind's pursuit of prosperity. Egg producers have made significant advancements in the quest to provide protein to an insatiable global population whose people persistently demand improved standards of living. And manufacturers of biomass power systems have likewise improved the design, functionality and application range of their units to meet increasing power and green energy demands. In Turkey, the union of egg and power production is underway.

FASTIDIOUS PRODUCTION: Güres Group in Manisa, Turkey, produces a billion eggs a year from 4 million laying hens, which produce 500 tons of manure that is deposited and collected daily through multilayer cage systems and conveyor belts.
PHOTO: GURES GROUP

In August, Turboden, a Mitsubishi Heavy Industries company that manufactures Organic Rankine Cycle turbogenerators for distributed power generation, signed an order with the largest integrated egg producer in the Republic of Turkey, Güres Group, for a new ORC unit to be installed at the company's main production site in Manisa, Turkey. In the press release, it stated Güres' annual production was an astonishing 800 million eggs.

"I would like to correct that our annual production is 1 billion eggs right now," says Turgut Oruc Yilmaz, a doctor of mechanical engineering with Güres Group who has served as technical coordinator with the company since 2014. Yilmaz says with recent investments, the company's production achieves 3 million eggs per day. The expansive operation covers 700,000 square meters with a closed area of 250,000 square meters, housing 4 million laying hens in 35 henhouses.

Yilmaz says Güres Group was founded by Ahmet Remzi Güres, one of the founder deputies of the Republic of Turkey, with only 600 hens. Today, it's Turkey's biggest and only fully integrated egg producer with 700 expert employees. "Güres has become this successful by mainly focusing on reliability, taste and customer satisfaction, rather than focusing on profitability," Yilmaz says. Innovative investments by the family operation have made Güres an industry leader, triggering inventions and advancements in feed mills; egg tray factories; incubation, pullet and breeder facilities; manure, cage and equipment factories; quail meat and egg production facilities, and more. Now, the company is again demonstrating its commitment to innovation by not only finding an environmental solution for its 500 tons of chicken litter per day, but one that also turns this otherwise troublesome mess into profitable green power.

Through multilayer cage systems, the company has historically collected its chicken litter—raw manure, sans bedding—with polyurethane conveyor belts underneath the chickens, conveying the waste to anaerobic fermentation reactors where the manure is converted to organic fertilizer. Yilmaz says after three days, the moisture content of the fermented manure drops to 35 percent. Then, it is transported by truck to a fertilizer manufacturing facility where a coal-fired boiler fuels a rotary drier to reduce the moisture to 20 to 25 percent for pelleting. The dried, fertilized manure is pelleted and sanitized at 80 degrees Celsius for an hour, and once it cools to 30 degrees, it is ready for packaging.

"To produce organic fertilizer from the raw chicken manure requires too much effort, time, labor and energy costs," Yilmaz says. "The selling price of the fertilizer is much lower than the cost of manufacturing." Furthermore, Yilmaz says, the fertilizer is sold seasonally, so the product could be stored on-site for more than eight months. "Storing such an amount of manure close to the farmhouses also creates a very risky situation for the biosecurity of the farm," he says. As a result, Güres began investigating other options.

With more than 50 years of experience, Güres has extensive knowledge of not just egg production, but also manure handling. The first and most important step in finding a better way to utilize its 500 tons of chicken manure a day was to define what type of system is the most convenient, feasible way to handle manure, Yilmaz says. "We did a deep research, literature review and investigation on both commercial and noncommercial systems around the world including gasification, pyrolysis, biogas, combustion and fermentation systems," he says. "After we compared the advantages and disadvantages of all those systems, we decided on combustion."

Enter Turboden

Turboden is an Italian firm and European leader in the design and production of ORC systems. Since 2013, the company has been part of Mitsubishi Heavy Industries. The company has built more than 355 plants in 38 countries, mostly concentrated in Europe—in particular, Austria, Germany and Italy, due to favorable policies and incentives for renewable energy and biomass cogeneration technology Turboden provides.

"In Turkey, we currently have 11 turbines, five of which are in operation with the remaining under construction," says Filippo Vescovo, deputy manager of Turboden's local company, Turboden Turkey. Vescovo is also responsible for all nongeothermal sales activities for Turboden in Turkey.

The first commercial plant delivered by Turboden was a biomass plant sold in 1997 in Switzerland. Before then, Turboden developed several pilot plants for research projects. Vescovo says since then, Turboden has constantly been improving its technology, thanks to its extensive R&D work, by developing larger size ranges, higher efficiency systems, improved plant reliability, new fields of applications and new working fluids.

Turboden's technology works by either combusting, or gasifying and combusting, the biomass to produce hot gases. The heat contained in the gases is then transferred to the ORC system by using a closed thermal oil loop, Vescovo explains. The ORC system, a closed thermodynamic Rankine cycle based on an organic fluid, which, as Vescovo says, is used in place of water, transforms the input heat into electrical power and heat at lower

enthalpy—a thermodynamic quantity equivalent to the total heat content of a system. "The heart of the system is the ORC turbine," Vescovo says, "which feeds with mechanical power a generator for the production of electric power. After the turbine, the excess heat contained in the organic fluid is dissipated through air coolers, or used to produce hot water or steam for cogeneration purposes."

Vescovo says the ORC system could be compared to the steam Rankine cycle. "The main difference," he says, "is the type of working fluid used, which is water in steam turbines and an organic fluid in ORC systems." Working with an organic fluid in place of water means variation in terms of the thermodynamic cycle and, therefore, in the design of the equipment, giving way to four main differences.

ORC turbines work at lower pressure levels and turbine speed, which imply lower mechanical stress in moving parts; thus, lower maintenance, skill and effort are required to operate. Also, no water in the turbine means no need for chemical treatment of the fluid. In addition, water-related corrosion and erosion phenomena in the turbine are nonexistent in ORC systems. Vescovo explains that ORC technology has much better performance in terms of flexibility at partial load. "Turboden's turbine can operate at any load between 10 and 110 percent of thermal input at higher efficiency levels," he says. "This is why ORCs are preferred in contexts in which thermal load may change, such as in the steel industry or other processes in which thermal levels change according to seasonality." Finally, ORC technology can operate with low-temperature hot sources down to 100 degrees such as geothermal water, while, as Vescovo points out, this is not possible for steam technology.

Yilmaz says Güres has been researching the combustion of chicken manure for the past five years. "The combustion of the manure is very challenging from a technical perspective," he says. "Due to its high amount of ash, alkaline, chlorine, tar and moisture content, the combustion system must be designed and developed very carefully by considering all those aspects." Otherwise, Yilmaz says, a host of problems can ensue. The system could fail rather quickly due to high-temperature corrosion. It would likely suffer from low thermal efficiency. Also, the unit may not be able to meet emissions regulations, and it would require frequent maintenance due to the ash agglomeration. Or, the system might need extra fuel, such as gasoline, to maintain required temperature inside the boiler. "In the past five years, we have performed our R&D work to solve all those issues," Yilmaz says. "We built a prototype two-and-a-half years ago, and conducted our functional and performance tests on it." Güres chose an ORC system by Turboden because, as Yilmaz says, the systems are easy to operate, safe and modular. Furthermore, ORC is able to run with a heat source less than 350 degrees, with more than 20 percent electricity conversion efficiency, he adds.

"Our fluidized bed combustion boiler heats the thermal oil up to 300 degrees," Yilmaz says. "Then it is delivered to the ORC's evaporator. It returns to the boiler at 260 degrees. Therefore, the metal surface temperature in our heaters can be kept less than 350 degrees, which is very important to prevent high-temperature corrosion on the metal surfaces. Otherwise, the system can fail in a few years."

Vescovo also says combustion of chicken manure is the biggest challenge of such a system. The three main challenges are its high ash content; the presence of undesired chemical compounds based on phosphorous, calcium, chlorine, sulfur and nitrogen; and its high moisture content—especially chicken litter from laying hens. While Vescovo says ash content from combustion of chicken litter is problematically high, Yilmaz says Güres plans to utilize the ash as a raw material in the production of organic-mineral fertilizer.

"In the Güres project, our ORC module will have two main tasks," Vescovo says. "One, to transform the heat generated by the combustion into electrical power at a high efficiency rate, and two, to collect the excess heat after the ORC turbine in a water-cooled condenser to generate 70-degree water that will feed the dryer system." The dryer system Vescovo mentions is a technology developed by Güres to reduce the moisture content of the manure before combustion.

"From all our work and experience," Yilmaz says, "we have learned that the manure—especially layer manure—requires predrying for optimum combustion efficiency, so we developed a new-generation manure dryer that can be run with a low-temperature heat source, such as 70-degree water." The dryer Güres developed can dry any manure from 75 percent moisture content to 25 percent in 24 hours, exclusively with this low-temperature heat source.

The dryer works in batches, mainly because the manure can only be collected from the farmhouses in an eight-hour window during the daytime. "We did not want to stock the wet manure because of its bad odor and biosecurity risks," Yilmaz says. "Furthermore, if one loads the wet manure on a truck, it loses its particle structure." He says once the manure's granulate structure is broken, it gets very hard to dry, requiring much more time and energy.

"In our drying system, the manure is collected from the farmhouses with a conveying system and is loaded directly into the dryer in two hours, and the drying is complete in 24 hours," Yilmaz says. "Therefore, there is no need for storing wet manure. Furthermore, the manure is only kept inside the farmhouse one or two days, which increases the comfort level of the air inside the house."

Yilmaz says the most critical emissions from this new endeavor come from the high nitrogen content of the manure. "The emissions quality and degree are all about how efficiently the manure is combusted and how successfully the flue gas is treated," he says. "The flue gas cleaning system in our project has been designed considering all emission regulations in Turkey." The emissions controls include flue gas recirculation, a wet scrubber, and multiple ash collecting and urea injection systems to meet regulations.

The 2.3 MW of electrical power produced by Turboden's system at Güres Group's main egg production site in Manisa, Turkey, will be sold to the grid at a special feed-in tariff specific for bioenergy. "The feed-in tariff system," referred to as YEKDEM, Vescovo says, "guarantees a base-tariff for the sales of electricity generated from biomass sources of USD$133 per megawatt-hour (MWh) for 10 years." Furthermore, this is even greater when locally produced equipment is used to produce the green power. "This tariff is improved by employing equipment produced locally," Vescovo says. "In the Güres project, the Turboden ORC turbine produced at our Ankara, Turkey, manufacturing facility will provide the customer an extra income of $20 per MWh for five years."

Vescovo wouldn't disclose the cost of the system being provided to Güres, but when Yilmaz was asked what Güres anticipates regarding a return on investment (ROI) for this project, he says, "This is still an ongoing R&D project and will be completed in July 2018, so it is hard to say an exact amount at this stage. Our target is to get the ROI down to five years."

If all goes well, Güres sees a future with this technology. "Güres Group also has a cage and equipment factory under the name of Güres Technology," Yilmaz says, "so after the success of the project, Güres Technology can sell this project to its customers. Hence, Güres Technology can increase its product range. We are sure that with Turboden's support, we will be successful."

Vescovo says, "I believe that in the near future we will see a large diffusion of this type of system around the

world. Country-specific factors like climate, economy, regulation framework and awareness to environmental issues will determine the speed of implementation of them."

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