Blue Mountain Biogas Plant Turns Pig Manure into Power

Bryan Orchard reports from Beaver County, Utah USA

According to the American Biogas Council (ABC), the USA has over 2,200 sites producing biogas, with 191 on farms, around 1,500 anaerobic digesters at wastewater treatment plants and 576 landfill gas projects. The potential for growth is huge and the ABC has counted almost 12,000 sites ripe for development, including 8,200 dairy and pig farms. By comparison, there are over 10,000 operating digesters in Europe.

Since these figures were published in 2012, the ABC can add another plant to its list. The Blue Mountain Biogas Power Generation plant in Beaver County, Utah came on stream in November. Developed and operated by Alpental Energy Partners of Provo, Utah, the US$17 million, 3.2Mw plant will generate electricity from methane gas provided by the anaerobic digestion of swine manure. Construction work started in early 2012 and the first power generation took place on the 27th November.

Alpental Energy Partners own and operate alternative energy power plants, and the two types that they favour are biogas and waste recovery. For the development of the Blue Mountain Biogas plant, Alpental brought together experts who could evaluate the potential of using pig manure to generate electricity on a commercial basis and design, plus construct a state-of-the-art plant.

Murphy Brown, which is a subsidiary of Smithfield Foods, operates pig farms in Beaver County, Utah the largest producer of pigs in the USA. The 10 farms on the 1,000 acre Blue Mountain site produce around 1million pigs a year, so there is a constant stream of manure available for biogas production. Until the construction of the Blue Mountain Biogas plant, all manure was transferred by the farming operation to settlements tanks, where it evaporated releasing harmful methane gas into the atmosphere. The biogas plant now exploits the commercial potential of the methane by using it to drive two power generators and also helps to reduce the volume of methane going into the environment thereby reducing the unpleasant odour.

Blue Mountain

Comprising waste treatment and anaerobic digesters, a gas scrubber and power generation hall, the Blue Mountain biogas plant has the capacity to generate 3.2Mw from two Caterpillar 3520 1.6Mw engines, this being sufficient electricity to power approximately 3,000 homes. According to Brady Olson, Vice President Alpental Energy Partners, his company expects to produce 25 million kW hours a year by operating on a 24x7 schedule. In order to build the plant in Utah, Alpental had to ensure that the liquid manure could neither contaminate the groundwater supply nor have an adverse impact on the air quality.

"What is good about this type of biogas project is that it has true measurable impact on air quality," says Brady Olson. "This is because methane is about 21 times more harmful to the atmosphere than CO^2, so essentially the methane destroyed by this plant is the equivalent to 100,000 tons of CO^2 each year. In addition, the odour is reduced."

The design and construction of the plant involved Alpental bringing in a local general contractor, Aqua Engineering which specialises in the design of wastewater and effluent treatment facilities and local equipment supplier W-Cubed. The production of methane gas as a fuel source is heavily dependent on proven sewage handling and anaerobic technologies, therefore Aqua Engineering was appointed to the project. The Salt Lake City based company has considerable experience in the design of waste to energy projects that produce methane gas from bio-solids to generate both heat and power. It was Aqua Engineering who brought in equipment specialists W-Cubed, also of Salt Lake City.

"Aqua Engineering has enjoyed a long working relationship with W-Cubed, which has been the sales representative for pumps and mixer manufacturer KSB of many years standing," reports Aqua Engineering President Scott Rogers. "My company uses a large number of pumps as it is highly active in the design and build of lift stations and pump stations. The ready availability of KSB submersible effluent pumps from W-Cubed, coupled with its ability to supply the pumps with panels, has led to us using KSB equipment for many of our projects. The KSB pump is a well proven piece of equipment within the waste water treatment industry. However, our involvement in mixing equipment has been contained to small mixers, so when it came to selecting the appropriate units for the Blue Mountain Biogas plant, we looked to W-Cubed and KSB Inc. for technical assistance, and we were not disappointed."

From Manure to Gas

The Blue Mountain Biogas plant operates by taking diluted manure from the 'finishing' barns into an influent basin (Fig1). From there it is transferred to a heat exchanger facility and then into two in-ground digesters. The resulting methane gas is vented into a scrubber tower where impurities are removed, then into two gas compressors where the gas is dried and pressure boosted to feed the two Caterpillar engines.

Fig. 1 Liquid effluent is pumped from finishing barns to a one million gallon influent basin.

The efficient operation of the biogas plant is dependent on a constant supply of pig manure from the 50 'finishing' barns. At any one time, there can be as many as 220,000 pigs at Blue Mountain and in the event of manure being in short supply, there is always the adjacent Sky Line farm containing up to 280,000 pigs.

The manure is mixed with water to reduce solids to between 2.5 and 5%. This slurry is constantly being pulled from pits adjacent to the barns and transferred to the collection stations at the biogas processing facility via a series of pump lift stations. Each collection station is equipped with KSB Amamix 2223/24UDG mixers and Amarex KRT vertical submersible effluent pumps (Fig.2). The Amarex KRT is a safe, reliable and energy-efficient solution for a wide range of pumping jobs in industrial wastewater engineering. In order to provide maximum versatility/flexibility for applications, KSB offers this pump in a multitude of materials. A range of specially adapted hydraulic systems with high operational reliability, due to wide free passages, make for optimum economic transport of all types of liquids.

Fig.2. KSB Amarex KRT vertical submersible effluent pump.

KSB's Amamix submersible self-cleaning mixers are used extensively throughout the wastewater and effluent treatment industries and can be installed in virtually any application. The backswept impellers generate maximum thrust at minimum power consumption, and units can operate at up to 1700rpm. These mixers are activated prior to the pumps being switched on in order to keep the slurry in a homogenous state before it enters the central influent basin. On a typical day, the influent basin receives some 750,000 gallons of slurry.

"The purpose of the 1 million gallon influent basin is to provide operational flexibility to the process," says Brady Olson. "The process of draining the barns is a manual one and it is necessary to feed the digesters with a constant flow of slurry that has a regular homogenous consistency. It means that the pits can be pulled when it is convenient to the operators." The influent basin contains a single 25hp KSB Amaprop hybrid submersible agitator with self-cleaning propeller that serves the purpose of inducing a suitable flow throughout the entire basin. This will prevent a build of solids below the two Amarex submersible pumps which transfer the liquid to the digester basins. The agitator is mounted on a guide mast located on the bridge extending above the surface of the basin and it can be turned through 180º in order to optimize mixing (Fig.3).

Fig. 3. KSB Amaprop hybrid submersible agitator with self-cleaning propeller is mounted on a guide mast located on the bridge extending above the surface of the basin.

Obtaining maximum gas yield depends heavily on precise and comprehensive agitation of the manure substrate. The Amaprop agitator prevents floating blankets on the surface of the substrate thereby shifting the chemical balance towards the substrate. The low speed, large diameter propeller moves the same amount of substrate at a lower flow velocity, so flow losses are reduced and the mixing process goes easy on the bacteria. Applications such as this influent basin are well suited to the hybrid Amaprop (1m diameter) which provides the effectiveness of a low speed agitator with the flexibility of a higher speed mixer. In this specific application Alpental's engineers have reduced mixer speeds in order to optimise the temperature (reduce heat loss to the atmosphere from rapid substrate turnover) of the liquid, as temperature is of high importance to actual anaerobic digestion process.

For the digestion process to be truly effective, the influent needs to be at a constant temperature of 98.5º. Prior to entry into the in-ground digesters the liquid passes through three heat exchangers to raise the temperature. The 30ft deep in-ground digesters are sunk into the ground and lined with concrete at the bottom and with a 60ml HDPE liner on the sides. Each digester has a capacity of 11 million gallons for a total of 22 million gallons.

In order to maintain the temperature at 98.5ºF both digesters are insulated by a floating cover. A recycling system is located in the heat exchanger hall which maintains the temperature in each digester. This recycling system pulls waste out of the digesters to be combined with the slurry coming into the heat exchangers from the influent basin. The Blue Mountain Biogas plant has been designed to optimise the methane gas produced and the heat created by the two generator sets. The heat reclaimed off the engines is used to heat the slurry as it comes into the plan as well as makeup for heat loss in the digesters themselves.

Mixing is an essential component of the 24 day digestion process and each basin contains four large blade (2.5m diameter) Amaprop K42-2500/65ZEG mixers rated at 8 hp (Fig.4). Positioned at the corners of the digester basins, the mixers are set at two different elevations, with two at 10ft off the bottom and two at 20ft off the bottom all pointing in different directions to create a circular pattern and to stimulate digestion.

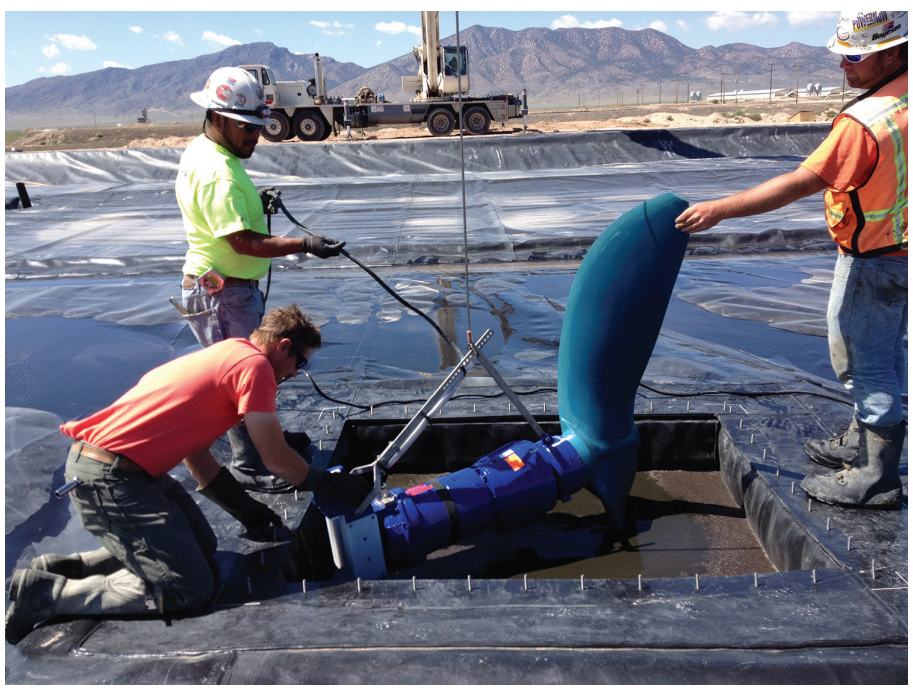

Fig.4. KSB Amaprop K42-2500/65ZEG mixer being installed in the 11 million gallon digester basin.

Aqua Engineering and W-Cubed had a major role in the design of the pumping and mixing systems. Commenting on this, Scott Rogers reports: "The preliminary design, which was not prepared by Aqua Engineering, contained mixers and pumps that we felt were not suited to the project. Together with W-Cubed and KSB Inc., we were able to show to Alpental that the design could be improved and that the project would be best served by using KSB Amaprop, Amamix mixers and Amarex KRT submersible pumps.

The original mixing design for the in-ground digesters called for small blade direct driven mixers to be installed. As Jared Wray, Product Manager Submerged Propeller Devices, KSB Inc. says: "When KSB got involved we offered our highly efficient large blade gear drive Amaprop 2500 mixers, which at only 8hp each saved significant power in just the large digesters alone. Originally the mixers were small high speed mixers of 40hp each. This solution was very attractive to both Aqua Engineering and Alpental because any saved power means more power which can be returned to the grid by the process itself."

To support its offer, KSB provided large installation lists showing more than 2,000 large blade units being sold in Europe as well as Computational Fluid Dynamics (CFD) modelling. Table 1 shows a comparison illustrating almost equivalent mixing for KSB's large blade mixers versus the most powerful small blade mixers on the market.

Table 1

APPROXIMATE PERCENT OF VOLUME MIXED TO SPECIFIC AVERAGE VELOCITY		
	Avg.Velocity of	Avg.Velocity
	5cm/s (0.16ft/s)	1cm/s (0.03ft/s
40hp small blade mixer solution	17%	28%
8hp KSB large blade 4 agitator solution	14%	24%

"The design first presented to us stipulated over 100hp worth of mixers per basin," says Scott Rogers, "but KSB was able to demonstrate that the design of its mixers would reduce the horsepower for each basin. This was important because it means that there is now more power available for export.

The methane gas produced is continuously drawn from the digesters and passed through a scrubber tower to remove hydrogen sulphide using bacteria. From there, it passes through into the primary gas compression skid and is passed either directly into the secondary gas compression skid or the flare stack (Fig.5). The secondary gas compression skid measures how much gas needs to go into the two generator sets or it can divert it to a standby boiler. Should one of the generators be taken out of service for any reason the standby boiler will burn the gas to produce the heat that may be required for the heat exchangers.

Fig.5. Methane gas is and passed either directly into the secondary gas compression skid or the flare stack.

Tracking and measuring the quantity of methane gas produced and destroyed for carbon credits is an essential process for the profitably of the Blue Mountain Biogas Power Generation Plant. The whole plant has been designed to optimise the methane gas content of the influent, minimise water usage and evaporate the digested waste in order to reduce the impact on the environment. In order to achieve this, Alpental Energy Partners have brought together the best technology available resulting in a plant that is both energy efficient and environmentally acceptable.

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