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Case Study

Biogas Effluent Treatment with VSEP

Biogas

As organic materials decompose in places where there is no oxygen, methane gas is created. Bacteria and other microorganisms "digest" the organic materials breaking them down into smaller and smaller pieces until the basic building blocks of the organics are formed. A cow's stomach works this way and methane gas is one of the byproducts. This also happens in landfills where the piles of garbage are kept in dark damp enclosures free of oxygen. Bio-degradation occurs and methane gas in generated. This gas is often vented and flared out of safety concerns. Sometimes this gas at the landfill is collected, cleaned, and burned to make electricity.

This natural process is now being employed as a way of creating "renewable energy". Many governments and utility companies are moving towards greater production of all types of renewable energy including wind power, solar, and even biogas which is the methane produced by anaerobic digestion of animal waste, agricultural waste, and many other forms of "biomass" material. Many countries now have 20-30% of the energy created from these renewable sources. This is a continuing trend and more and more biogas plants will be built in the future to feed the demand for this type of energy. You could say it is the wave of the future.

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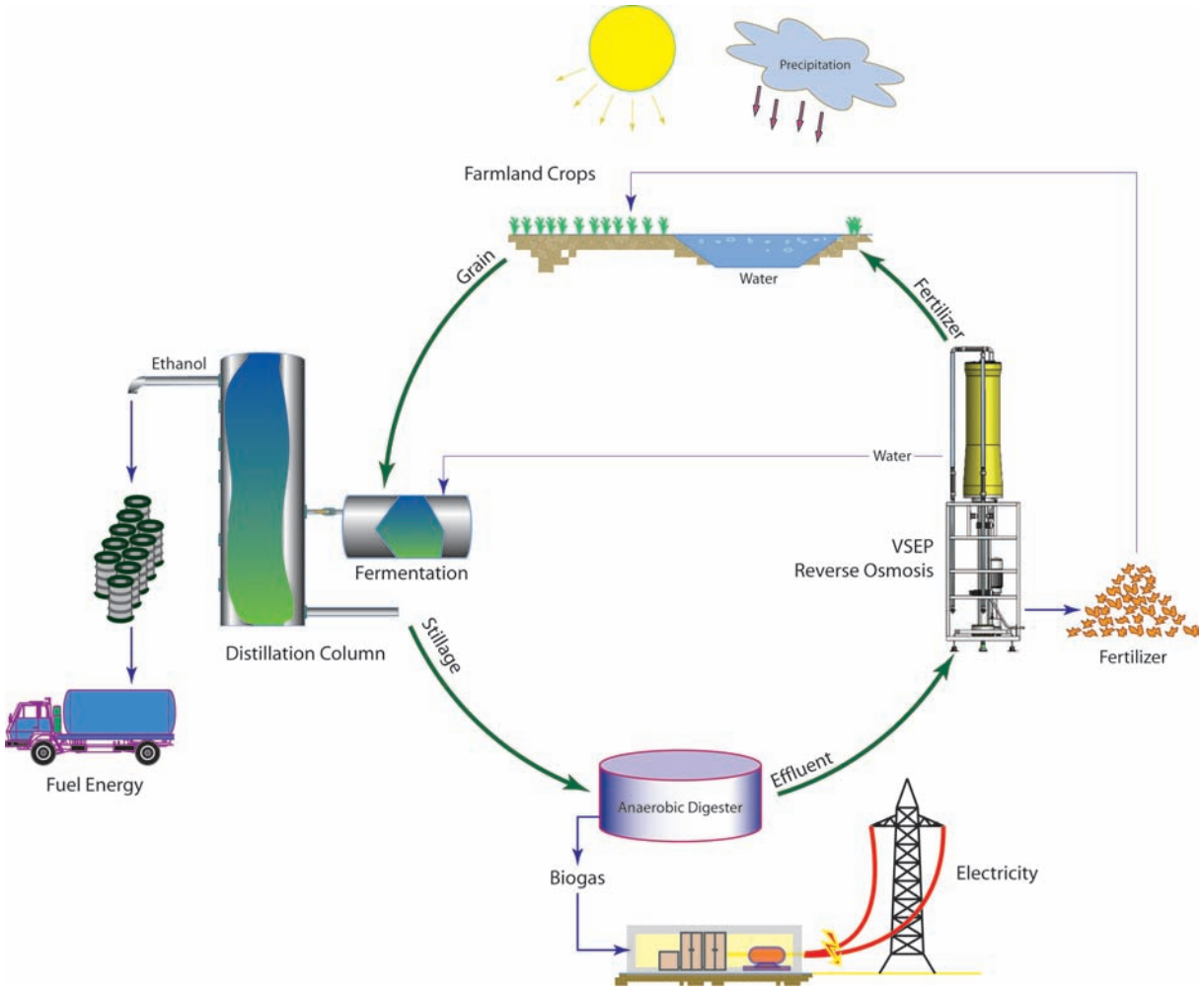
Biogas can be created from just about any organic material. Solar needs the sun to shine and won't do well in Northern hemispheres, where the days can be short. Wind power, of course, needs lot of wind. There can be windy days and calm days and wind is not always available. When the world's hydrocarbon supply is depleted, like in the case of Mad Max, biogas would make sense. Organic materials can be used anywhere in any region and can be locally harvested with no need for large tanker ships to come halfway around the world.

Kurana's Bioethanol/Biogas Plant

Kurana operates an ethanol and biogas plant located in central Lithuania. They have developed a unique process where they produce many valuable products from several types of grain. Wheat, Triticale, and Rye are produced locally and these are the basic feed stocks to the Kurana process. With these grains, the plant first produces bioethanol after fermenting to get the alcohol byproduct. The ethanol is recovered after fermentation using distillation. The distillation residue (stillage) is then put into an anaerobic digester where bacteria convert the organic components into methane gas, or biogas. This gas is then burned to make electricity. After digestion, the solids are recovered using centrifuges and VSEP and other equipment to make a fertilizer product. Finally, clean water is recovered with the VSEP RO membranes. The process is truly closed loop and nothing goes to waste. All of the components are recovered as some type of value added product.



The raw materials used for the process are grains that are grown locally. Because of this transportation costs and environmental impact are low. In order to get good methane gas production in the bio-digester, they also add slaughterhouse wastewater and milk wastewater hauled from local companies nearby.

The outputs from the Kurana plant include ethanol fuel, biogas, electricity, fertilizer, and water. There is zero-waste. Kurana sells the ethanol as a fuel to local fuel companies for blending with gasoline. They use about half of the electricity made from biogas to run the plant and they sell the other half to the local utility company putting it on the electrical grid. The fertilizer produced is supplied to local famers. The clean water generated is recycled and added to the fermenter.

The plant processes 60,000 tons of grain to produce 18,000 tons of ethanol. The stillage is digested to produce 26 million m3 of biogas which when burned has the capacity for 16.54 MW of electric power.

A closed loop water and wastewater process was needed due to the short time available for land application for digester effluent. There are only a few months during the year when fertilizers and irrigation can take place, as the growing season is short. Rather than storing large volumes of nutrient rich digester effluent, Kurana decided to include a fertilizer recovery and concentration step into the process. By doing this, concentrated fertilizer can be easily stored during the winter months. Another benefit is that the concentrated fertilizer then costs less to haul and they also get clean water back for the process.

Project Background

The digester effluent from Kurana has about 2% total solids (98% water). A centrifuge is used first to remove much of the suspended solids and these solids are collected and make up part of the fertilizer product. The filtrate from the centrifuge originally went to a multi-step process that included lime clarification, additional centrifugation, ammonia stripping, and finally a spiral reverse osmosis (RO) unit. Some problems occurred with a previous design:

1] The Clarifier bottoms plugged up the centrifuge and its use was discontinued. After this, the clarifier bottoms were then hauled as sludge.

2] The Clarifier does not remove enough suspended solids and especially without the Centrifuge, the Ammonia Stripping Column would get badly fouled and needed frequent cleaning.

3] The RO spiral system was not able to handle the suspended solids loading from the Clarifier and Ammonia Stripper. Because of this, eventually, the wastewater was hauled away as well.

So, Kurana did have a functioning way of collecting some suspended solids using the centrifuge, but was not able to get to a full closed loop process. VSEP was proposed to de-bottleneck what they already had in place.

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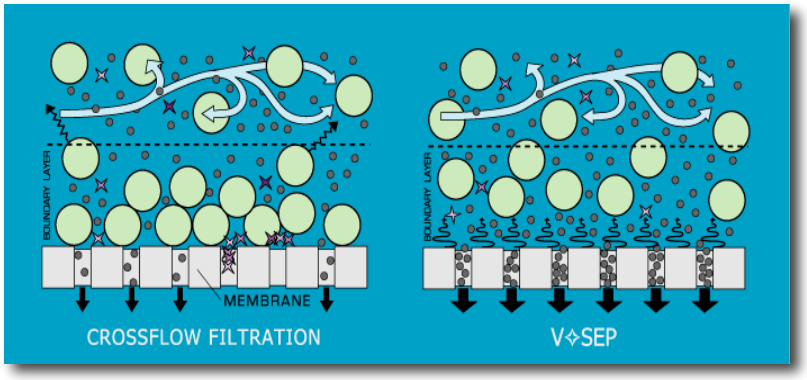
VSEP Process

VSEP uses polymeric permeable membranes that employ a wide feed channel between membranes to allow passage of suspended solids. It also uses a resonant frequency to vibrate the membrane surface 50 times per second. The shear waves created from this vibration resists fouling and scaling of the membrane surface and allows for efficient filtration rates and minimized cleaning frequencies compare to other membranes.



VSEP stands out with its simplicity, reliability, and economical benefits. Conventional membranes are limited in their abilities. Particles can become lodged in the spiral membrane module and the pores can be blocked from fouling and scaling. This will cause reduced flow and permeate recovery as well as more frequent cleanings. A laminar boundary layer will form at the surface of the membrane resulting in a formation of a barrier that restricts permeate flow. By applying a shear force to the surface of the membrane to disrupt the boundary, these problems can be decreased or even eliminated.

The VSEP is a cross flow membrane that is able to produce economical flow rates and reliability with fouling resistance due to the vibrations. The membrane vibrates at a 3/4" displacement at 50Hz. The vibration keeps the turbulent flow at the surface of the membrane allowing large molecules to continue movement away from the surface, avoiding fouling and allowing the water to pass through the membrane.

VSEP comes in a variety of sizes to accommodate different process sizes and the number of units required is calculated based on total process flow. Being modular, the ability to add additional machines is simple. Filter packs can be changed and different membranes can be used on the same machine for a variety of applications. This unique system has many advantages over conventional membranes and also other technologies for the same application. VSEP can process much higher concentrations of feed. The feed can come from a variety sources and can vary in composition. The VSEP is designed to handle this variation in feed quality without sacrificing product quality.

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Kurana's VSEP Process

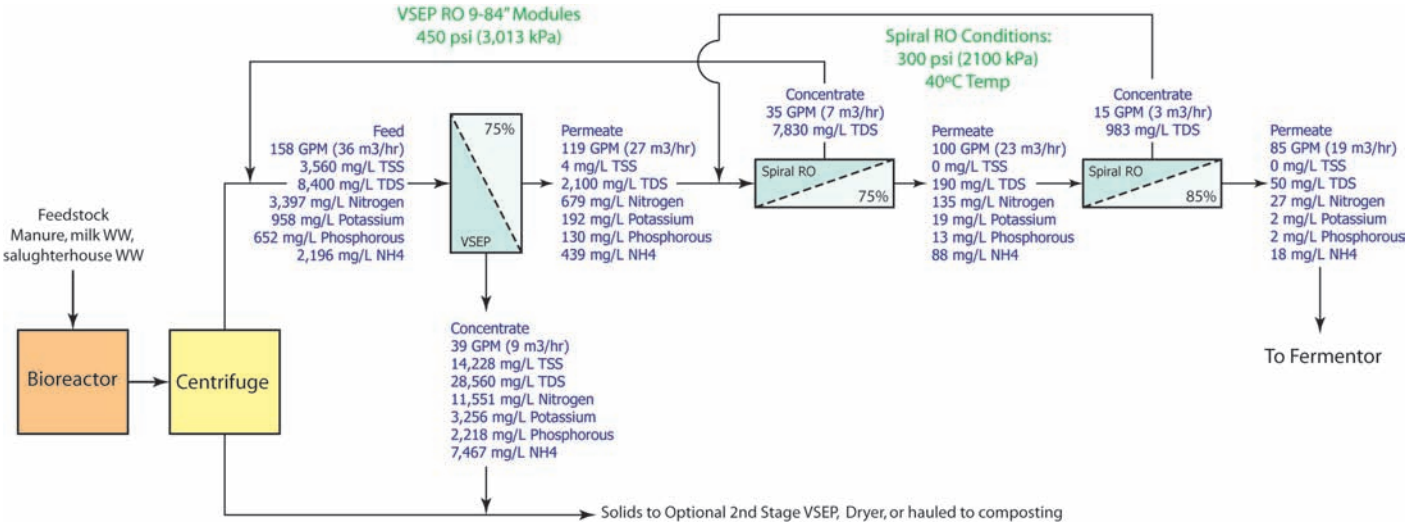
Digester effluent is very high in suspended solids, organics, sulfates, and other materials that would foul a conventional spiral RO membrane. This proved true in this case as the spiral system installed did not work very long. New Logic designed a multi-pass RO membrane system for Kurana. At first, New Logic looked at using Nanofiltration membranes in the VSEP followed by two stages of spiral RO to remove Ammonia. However, later it was decided to use RO in the VSEP so that the TDS feeding the following spiral systems would be low enough for these to run problem free.

The three main objectives for the new process were:

- Effluent capacity of 36 m3/hr
- Smallest volume of reject left as possible
- Needed <100mg/L (ideally) of Ammonia to reuse in fermentation

Reverse Osmosis membranes are the tightest of all membranes and can even reject the smallest dissolved solid. Since Ammonia is a soluble gas, it is even more difficult to reject using membranes. Each pass through an RO membrane will reduce the Ammonia levels by 80-90% depending on the pH. Rejection is generally better at lower pH when the Ammonia is present as Ammonium (NH4). At elevated pH, the Ammonia is there as a gas (NH3). Kurana wanted clean water back that could be used in the fermenter and added with the grain feedstock. Too much Ammonia would inhibit the fermentation process and minimize the yield of ethanol produced.

To achieve the low levels of Ammonia needed, New Logic installed a three-pass RO system. VSEP with RO membranes is used as the primary stage since it can handle the high suspended solids loading and is resistant to the fouling materials found in the digester effluent. Then, the filtrate from the VSEP is sent to a 2nd stage RO spiral system. The VSEP filtrate if free of suspended solids and other materials that would foul the spiral system. Finally, another polishing stage of RO spiral is used to get the Ammonia levels to less than 100 mg/L.



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The reject from both stages of spiral RO is sent back to the front of the previous membrane stage. The VSEP reject is where all of the concentrated nutrients can be found. VSEP is producing approximately 75% of the volume as clean water and is leaving a reject volume of about 25%. This is the material that is stored during the winter and land applied as fertilizer in the summer. Other VSEP installations for digester effluent use a dryer to make the VSEP concentrate a dry fertilizer product that is bagged and sold. The hot air coming from the cooling of the electrical generators is used to dry the reject. This method can be used when the fertilizer will be actually used a long distance from the biogas plant. In this case local land application is used and so hauling costs are not that much of a concern.

Summary

New Logic Research has supplied VSEP membrane separation technology successfully into many industrial processes and has several biogas effluent installations. The development of the biogas industry, along with the availability of new membrane materials and VSEP technology make it possible to deal with the very difficult digester effluent stream with successful economic results.

The commercial biogas plant design has been constantly evolving. Improvements are being made to boost methane production. Many of these biogas plants are bring constructed using private financing that is based on the amount of methane that can be produced. Often, the investments are made and construction begins without adequate thought about what to do with the wastewater that is generated, or also, what other value added by-products can be harvested.

Each application that comes to New Logic goes through rigorous tests and each system conditions are customized. The process begins with an initial feasibility test using lab scale VSEP machines. An important characteristic of VSEP is that just about

any membrane on the market can be cut and inserted into the VSEP to meet desired filtration needs. A variety of membranes are tested based on the application and the best membrane continues to test different variables including pressure, temperature, pH, %recovery, and others. Further testing is completed onsite with pilot machines. New Logic works with a wide range of applications from food products, landfill leachate, RO reject, all types of wastewater to even hog manure and works to meet each individual application's objectives

Contact a New Logic representative to develop an economic analysis and justification for the VSEP in your system. For additional information and potential application of this technology to your process, visit New Logic's Website @ http:/www.vsep.com or contact New Logic.

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