FOOD WASTE ANAEROBIC DIGESTION

Over a billion tonnes of edible food – equivalent to almost one third of global production – is wasted annually by the world. This would be enough to feed three billion people, according to a recent report by the Food and Agriculture Organisation of the United Nations.

Clearly, waste minimisation is the priority activity to address this situation. Logistics should be improved to reduce losses. However, a certain amount of food is inevitably wasted. With the possibility of producing 0.7 MW net of electricity on a continuous basis from every 100 tonnes per day, one billion tonnes a year represents a potential of 7.0 gigawatts of continuous electrical power.

Subject to location specifics, such as moisture and volatile solids content, 100 tonnes per day will also produce enough biomethane to fuel 25 buses on a continuous normal working-day basis, avoiding the use of 35 tonnes of diesel per week. Furthermore, for every 100 tonnes of waste that does not go to landfill, around 25 tonnes of compost is produced.

Although the potential is there, the process is not necessarily simple. Whilst food waste is globally of a similar composition, it is managing the differences which proves key to success in energy recovery. In order to implement a food waste to energy project it is necessary to define the range of inputs and to establish the viable capacity for a commercially operating facility.

Commercial food markets represent a viable option for consideration, subject to residual waste capacity. Raw municipal solid waste may also be considered a viable feedstock, although front-end separation will require greater functionality to provide a bio-digestible organic feedstock to an anaerobic digester. For this form of waste, the reject component being typically in the range of 40% to 50%, whereas market waste rejects may be as low as 1% or 2%.

COMPONENTS INVOLVED IN A FOOD WASTE-TO-ENERGY SYSTEM

Source separation

Feed preparation

Front-end processing

Anaerobic digestion

Ammonia control

Hydrogen sulphide control

Biogas pumping equipment

Biogas processing systems

Burners and/or power generation equipment

Compressed biomethane preparation and dispensing

All of the above items are available directly from Organics using project-proven proprietary technology

ISO 9001 REGISTERED FIRM

ENVIRONMENTAL MANAGEMENT SYSTEM ISO 14001

PROJECT ROUTE

Organics has developed a project delivery structure for food waste anaerobic digestion projects over many years that ensures reliable completion and quality control whilst maintaining specification requirements, and time-schedules.

WASTE STREAM CHARACTERISATION

Waste stream characterisation involves two primary subject areas: (1) rate and composition of waste arisings; (2) analysis of waste biodegradability. The first is achieved with an on-site sampling campaign, the second with laboratory analyses and Bio-Methane Potential (BMP) testing.

SITE ASSESSMENT AND SPECIFICATION

Establishing a clear statement of the practiical design parameters is the first step in determining scope. This will require a detailed study of each specific situation.

DESIGN

Each project is designed as a unique entity to ensure that all details are fully addressed.

PROCUREMENT

The procurement function takes full responsibility for maintaining delivery schedules. Their remit is from drawings and component specification through to all parts ready for final fit-out and commissioning.

MANUFACTURE

Manufacture may either be completed to "good engineering practice" or, where specifically requested, under the supervision of a Third Party Inspector, such as Lloyds.

INSTALLATION

Installation can be a complex process and requires careful planning.

COMMISSION AND HANDOVER

Established procedures are followed to ensure that equipment is fully operational at

WASTE RECEPTION / FRONT-END PROCESSING

As with other aspects of such systems, the reception and front-end processing for a specific facility will be organised subject to local requirements and conditions.

In the general case, waste collection vehicles will pass through a weighbridge to keep a record of the mass of waste received. It would then be discharged into a bunker at the tipping bay. This method is employed to facilitate a high volume of incoming waste vehicles at peak hours, which can occur generally two or three times a day.

The enclosed tipping bays will normally be equipped with double-doors and a deodorisation system to prevent odour from escaping to surrounding areas.

A grab crane may be used to transfer waste to the process train, normally commencing with a bag opener. The process train for preparation of waste for the anaerobic digestion process may consist of several additional items, all of which, or only some, may be used.

With heavily contaminated waste, such as kerb-side collected municipal solid waste, the items employed would typically be a bag opener, a crusher a hand-picking line and a trommel, prior to a hydraulic separator and a pulper. The suspension may also pass through a sand grit trap where heavy impurities such as glass, stones and sand, etc, are removed. Metals will also be separated from the food waste for recycling.

Where the waste is source separated, contamination may be low. In such cases it may be possible to dispense with some, or even all, of such processing equipment.

The objective remains the same: to remove non-biodegradable fractions from the incoming waste, to prepare the particle size and the moisture content of the feedstock to facilitate optimum anaerobic digestion.

ANAEROBIC DIGESTION

Anaerobic digestion involves the breakdown of organic waste by bacteria in an oxygen-free environment. It is commonly used as a waste treatment process but also produces a methane-rich biogas which can be used to generate heat, produce electricity or, after cleanup, be used as a vehicle fuel.

Anaerobic digestion equipment consists, in simple terms, of an anaerobic reactor volume and a gas holder to store the biogas.

Organic waste is broken down in an anaerobic digester with up to 95% of the biodegradable organic content being converted into biogas. The rate of breakdown depends on the nature of the waste, the reactor design and the operating temperature. Biogas has a calorific value of typically between 50% and 70% that of natural gas and can be combusted directly in modified natural gas boilers or used to run internal combustion engines.

Organics offers a number of anaerobic digestion systems suitable for varying feedstocks and specific operating conditions.

The process of anaerobic digestion (AD) consists of three steps:

The first step is the decomposition (hydrolysis) of plant or animal matter. This step breaks down the organic material to usable-sized molecules such as sugar.

The second step is the conversion of decomposed matter to organic acids.

Finally, the acids are converted to methane gas.

Process temperature affects the rate of digestion. Usually, it will be maintained in the mesophilic range (30ºC to 35ºC - 86ºF to 95ºF). At higher temperatures the process requires a greater degree of attendance and understanding.

BIOGAS FEED TRAIN

A typical biogas feed train will consist of a prime mover, to drive the biogas through the various items of equipment involved and deliver it at the correct pressure to the point of use, gas cleaning equipment, typically for hydrogen sulphide reduction and/or siloxanes, gas filtration and gas dewatering facilities.

Gas dewatering may be accomplished to acceptable levels with a simple air-blast cooling system, although to prevent condensation it may often be necessary to employ a chiller. This unit can drop the dewpoint to below ambient conditions. As well as the general difficulty of having water condensing in gas burners or gas engines, the condensate can also pick up trace gases in the biogas, leading to highly corrosive acids, such as sulphuric acid, coming from hydrogen sulphide combined with water.

Organics has considerable experience with building biogas feed trains. Each application and each type of biogas needs to be assessed in its own right. Pressure losses through the system, temperatures and relative humidity all need to be taken into account when optimising design. As much as is possible, Organics specialises in mounting equipment onto factory-built skids, or into ISO containers, thereby simplifying installation.

As well as standard packages there is often a requirement to address specific issues and specific requirements. Removal of carbon dioxide, in whole or in part, will be necessary for the use of biogas as a vehicle fuel. Removal of oxygen and nitrogen may be necessary where these gases are found to be entrained and cannot be removed by means of prevention.

BIOGAS UTILISATION

Biogas may be used in several ways to recover both energy and greenhouse gas credits. Where methane is destroyed and fossil fuel is offset, credits may also be available.

The simplest route for biogas utilisation is to pipe gas to a boiler or a kiln. As with all green-house destruction, it is essential that the actual destruction of methane is proven beyond any doubt.

Should such an option not be available at a specific location, as is often the case at food waste facilities, the next option is to generate electrical energy, either for in-house use or for sale to the national electricity grid. In either case, the electricity produced should preferably be used to offset fossil fuel electricity, such as power from diesel engines.

One further option is that of converting biogas into bio-methane. This involves the removal of carbon dioxide from biogas and the compression of the balance-methane to approximately 3600 psig (250 bar). This technology draws upon global experience with CNG in vehicles. Compressed Bio-Methane (CBM) may be suitable for vehicle use and creation of carbon credits but careful attention must be paid to the problem of destruction-verification. Simply put, it is difficult to prove methane destruction in a vehicle that is travelling around, although the environmental benefit is clear.

As with anaerobic digestion, each technology has its own optimum point of application. The decision as to which route to take is a function of cost, opportunity, technology and practicality. Organics can assist in such decisions from a perspective of knowledge, experience and familiarity with all relevant costs.

KEY FEATURES

TURNKEY DESIGN, MANUFACTURE AND INSTALLATION OR COMPONENT SUPPLY ONLY

FINANCE AVAILABLE THROUGH AFFILIATED COMPANIES FOR BUILD, OWN, OPERATE AND TRANSFER PROJECTS

OPERATION AND MAINTENANCE SERVICES PROVIDED

A ONE-STOP SOLUTION FOR A COMPLETE SERVICE RELATING TO THE DEVELOPMENT OF RENEWABLE ENERGY PROJECTS

The objectives of a project designed to recover energy from food waste are:

- The installation of an anaerobic digester which will generate biogas and reduce waste flows to landfill
- Reduction of odours and harnessing energy in the form of methane
- Generation of renewable electricity to offset the use of fossil-fuels
- Production of compost
- Where applicable, reduction of greenhouse gas emissions and creation of Certified Emission Reductions (CERs) by reducing greenhouse gas emissions

Organics is equipped to supply individual components within a complete system or all of the components required to make up a complete system. Organics has been active in this sector since 2002 and has a wide experience with all elements of such systems, from equipment design, instrumentation set-up for CDM compliance and CDM compliant gas flaring to gas production technologies as well as energy generation using engines operating with biogas.

MULITPLE WASTE TYPES

There are many different sources of food waste. These range from fruit and vegetable market waste, through restaurant waste to kerbside collected municipal solid waste. The waste types may be relatively clear of contamination or highly contaminated.

The source of the waste and the degree of contamination will impact upon the front-end processing required and hence the facility cost. An anaerobic digester should ideally be supplied with a consistent quality and type of feedstock to maintain a healthy and productive microbial community. This will result in consistent organic decomposition and biogas production, whilst minimising operational issues.

It is necessary to ensure that feedstocks are free of toxic and inorganic contaminants that will damage the intended microbial processes. Sand, gravel, and other inert materials should be removed to the extent possible to minimise sediment accumulation in the digester. Feedstocks from outside sources should be routinely characterised to monitor consistency.

Of primary importance will be the technology selected to homogenise and macerate the feedstock solids. The advantages will be an increased surface area being available to the microorganisms as well as ease of pumping.

PROCESS REQUIREMENTS

Waste arisings often arrive irregularity to the point of processing. If necessary buffering capacity will be required to accommodate mass flow peaks. It is also possible that some form of pre-treatment may be required, such as pH adjustment or hydrolysis. Batch or continuous operation are also options to be evaluated in the front-end feasibility study, subject to feedstock mix, feedstock availability and the general operating environment.

Temperature controls on the tank are optional, depending upon ambient temperature expectations, the source of the substrate and the planned length of the storage period. It should be noted, however, that the norm is to manage temperature as a part of a tank-based facility. Anaerobic digestion is an exothermic process, the magnitude of which is a function of the specific materials being treated. Methanogenesis is highly sensitive to temperature, so any changes of as little as a few degrees can have an impact upon performance.

Mixing within an anaerobic reactor is also substrate specific. The options range from occasional mixing to continuous. It is important to maintain the correct degree of mixing in the anaerobic digestion tank in order to avoid the build-up of a scum on the surface or prevent the separation of elements within the substrate. The mixing action also provides increased contact between the microorganisms and fresh substrate, as well as reducing the accumulation of settleable solids in the bottom of the tank.

A lamellar filter may be employed to retain sludge within the anaerobic digester, rather than allowing it to depart with the effluent. An option here is to employ a Ultra-Filtration membrane as a filter, to facilitate sludge retention.

SPECIAL CONSIDERATIONS

Whatever the source of the food waste, be it collected kerb-side waste or market waste, there will inevitably be contamination of the feedstock. Front-end processing can reduce this contamination to a great extent but cannot remove it completely. If, for example, the residual mass of stones, ash and glass, etc, is 1% of the feedstock, this would represent 365 tonnes a year of contamination being passed into the digester in a 100 tonne per day facility.

In such a case, keeping the internal system fully operational will either require sophisticated internal cleaning facilities or the recognition that a digester must occasionally be taken off-line for cleaning.

In the latter case, cleaning can be a complex activity requiring personnel entry into hazardous confined spaces, as well as specialised equipment.

Organics

Organics Group plc

Sovereign Court II
University of Warwick Science Park
Coventry CV4 7EZ,
United Kingdom
T: +44 (0) 24 7669 2141
F: +44 (0) 24 7669 2238
E: comms@organics.co.uk
W: www.organics.co.uk