Paper:
Horan, NJ and Smyth, M (2011) *The Complete Picture.* Chartered Institute of Waste Management Journal.

The Complete Picture

Nigel Horan and **Mathew Smyth** of Aqua Enviro critically assess the factors and drivers of anaerobic digestion, including the challenges it presents from the time of its inception to its smooth running to get a complete perspective

There are very few people in the waste industry who are unaware of the current interest in anaerobic digestion as a favoured option for recovering energy from waste. Although perhaps even fewer may be aware that it is a centuries old technology and was providing gas for street lights in some English towns as far back as the 1930s. A significant increase in the number of anaerobic digestion facilities is predicted in England and Wales over the coming decade and a Defra strategy is now in place that has targets for 1 000 new digesters to be built by 2015, which requires construction of around three new digesters each week.

The feedstock for these new digesters is predominantly food waste and the organic fraction of municipal waste, currently sent to landfill, together with farmyard manures that are spread on land. At first glance this appears to be an overly ambitious target, since over the past five years only around 80 anaerobic digesters were built in England and Wales. But by contrast, over the same period, more than 4 000 digesters were constructed in Germany. Although this puts the nugatory achievements of the UK into perspective, it does demonstrate that the proposed Defra ambitions are eminently achievable. However the UK was in a similar position before and during the mid 1980s when digestion was heralded as the ideal route for treatment of the UK's liquid

industrial organic wastes. Many novel processes were introduced such as the Upflow Anaerobic Sludge Blanket (UASB); Expanded Granular Sludge Blanket (EGSB) and the Anaerobic Filter. Unfortunately much more was promised from these technologies than they could ultimately deliver and the initial rapid take-up underwent an equally rapid decline, leaving many dissatisfied clients operating inappropriate technology. This article aims to explore both sides of the digestion coin and attempts at learning from the mistakes of the 80s and 90s to ensure that this time round, digestion is here to stay.

Legislative Drivers

THERE ARE several convergent reasons to explain the current interest in anaerobic digestion. It is viewed by Defra as an ideal vehicle to deliver a number of government targets such as greenhouse gas reduction and generation of renewable energy. For local authorities its main attraction is the diversion of biodegradable organic waste from landfill in order to meet the requirements of the EU Landfill Directive. And, of course, for the operators, the main incentive is a financial one: anaerobic digestion is also a source of income, from gate fees for the wastes received and the energy produced in the form of methane gas. However, it is important at the outset to clearly define the reasons for considering digestion. For instance, if diversion of organic waste from landfill is your sole aim, you may be surprised to discover that at the end of the digestion process you actually have a much larger volume of waste to dispose of than you started with, although its organic fraction will be considerably less. If the main reasons are financial ones then there are a number of routes to exploit the energy value of methane, including Combined Heat and Power (CHP), Liquid Petroleum Gas (LPG) and direct injection to grid. The most economically attractive route will

It is viewed by Defra as an ideal vehicle to deliver a number of government targets such as… renewable energy generation

depend on individual circumstances but the decision will be weighed by the many government subsidies in place to encourage renewable energy generation. Renewables Obligation Certificates (ROCs) have been around for some time and are well understood, but the impact of Feed-in Tariffs (FITs) and the opportunities that might arise from the Renewable Heat Incentive (RHI) are currently less well understood. In addition, potential synergies with an organisation's carbon reduction commitment are not yet fully explored and there is currently a lot of work underway to examine and ▶▶

understand the financial implications of each of these exploitation routes.

Net Energy Yields

THE NET energy yield from digestion is determined from the methane yield achieved under operational conditions minus the energy losses involved in feedstock transport and handling prior to digestion, digester heating and mixing and the costs of digestate handling and disposal. Methane typically yields a range from as low as 0.2Nm^3 methane/kg VSrem for poor feedstocks, such as farmyard manures, to more than 0.5Nm^3 methane/kg VSrem for high quality feedstocks, such as food waste. The key to optimising this yield is to optimise the VS removal, which in turn requires that attention is paid to digester operation and maintenance.

The internal costs of feedstock processing and digestion typically account for about 15 percent of the energy yield and this cost is relatively stable for the life of the asset. By contrast the energy associated with feedstock delivery and digest recycling is solely dependent on the transport distances involved. Thus if the source of feedstock changes or a digestate recycling route becomes unavailable, then the net available energy may drop to unsustainable levels. It is important, therefore, to have secure sources of feedstock and digestate recycling routes supported in order to prevent the scheme spiralling into an energy deficit. This in turn requires that long-term contracts are in place both for quantities and costs of feedstock and the availability of land suitable for digestate recycling.

Operational Issues

IT IS a mistake to consider a digester as a black box into which waste enters and methane leaves. It is in fact a complex biochemical reactor involving phase changes from solids to liquid to gas, and it requires the interactions of a delicate consortium of bacteria. Regular monitoring of digester health is essential and so is the provision of trained operators who are able to interpret and act according to the information provided. When digesters fail, it is a lengthy procedure to bring them back to health and this may take 28 days or more to achieve. And during this time period no waste is processed and no methane generated. In view of the large loss of revenue this will entail, "right first time" is the only philosophy to adopt in operator provision and training and the staff time needed for successful operation should not be underestimated.

For many facilities, the fate of the digestate or the end-product will dictate the overall financial viability of the scheme and determine the payback period. Digestate is recognised as providing a valuable source of nutrients, nitrogen and phosphorus, and as fears are now being raised about the future availability of phosphorous, the so-called "peak phosphorus", it is suggestive of the fact that the economic future of digestate is secure. Unfortunately, digestate is produced at a very low total solids concentration, typically between four and six percent. Thus, unless the digester is sited conveniently close to the point of digestate recycling, the transport costs will be high and it will not be viable to transport digestate without first thickening and dewatering. The digestate does dewater easily to around 25 to 30 percent solids, but in this case much of the nitrogen and phosphorus is lost in the dewatering liquor. This not only reduces the market value of the digestate, it leaves a liquid residue that requires expensive additional treatment to render it environmentally benign.

A number of options have been proposed to handle this liquid residue and produce a solid, slow-release fertiliser with a high market value and low transport costs, but these have not been evaluated in the UK market place. At present the market for both digestate and dried fertiliser is quite rudimentary with few established supply chains in position. This is one area that is expected to change rapidly over the next few years and is a priority for both WRAP and Defra. A guaranteed market for the digestate together with the technologies to render it fit for these markets will be a major impetus for the financial success of many digestion schemes.

Other Side Of The Coin

ANAEROBIC DIGESTION is one of many options for the recovery of energy from wastes. When sited close to an appropriate source of feedstock and with a guaranteed digestate recycling route close by, it is perhaps the most environmentally beneficial alternative by virtue of reduced GHG emissions, renewable energy generation and recovery of nutrients and recycling them back to land. Government subsidies are generous for the renewable gas, electricity fuel and heat that digestion produces and they also appear to be guaranteed over a typical digester planning horizon.

But digestion has disadvantages that must be carefully weighed and evaluated. Although it destroys much of the organic material in the waste it does not reduce the volume for final disposal, but actually increases it. As a result, management of digestate with effective and economic digestate recycling are key to the success of the process. Although its financial viability relies heavily on subsidies, the gate fee for potential waste feedstocks, which at present is very attractive, is also a major financial consideration. But as more digesters are built, competition for feedstocks is likely to drive gate fees downwards.

We may arrive at a contradictory situation whereby, rather than encouraging the reduction of waste generation, the plethora of new digesters require increased waste production in order to feed them all and thus warrant the capital investment. Finally it must be stressed that digestion is not a simple process to operate and without due care, attention and investment in operational expertise it will almost certainly fail. CIWM

…digestion is not a simple process to operate and without due care, attention and investment in operational expertise it will almost certainly fail