Making the most of waste

There can be tremendous environmental and commercial benefits from treating waste as a feedstock resource, rather than as a problem to be buried in landfill or burned in incinerators.

TEI Times looks at an innovative technology approach to energy from waste.

As part of a strategy to produce green energy from municipal waste, in April this year UK-based Waste2Tricity (W2T) acquired exclusive rights for deployment of AFC Energy's fuel cells in the UK energy-from-waste sector. Its objective, says the company, is to "apply the most efficient and economical technologies to achieving effective conversion of scrap carbon to electricity".

W2T says that compared to any alternate technology, the significantly higher efficiency of using AFC Energy's technology with high temperature gasification, means it can produce more electricity from the same amount of feedstock.

Peter Jones OBE, chairman of Waste2Tricity (W2T), a Fellow of the Chartered Institute of Wastes Management (CIWM) and until recently the mayor of London's special advisor on waste, explained: "By integrating these alkaline fuel cells with proven conversion technologies we can increase electricity output by up to 130 per cent – from the same amount of feedstock."

Jones: waste has an important part to play in decentralised generation

Three years ago W2T identified the need for high temperature gasification, high temperature meaning more than 1100-1200°C, to ensure clean syngas to remove the impact of tars etc. on the clean-up stage but also to maximise the conversion of carbon in the feedstock to useful energy gas.

Jones recalled: "At that time the only commercially proven technology was the Westinghouse plasma [process] being developed by AlterNRG, which reduces parasitic losses by using the plasma to assist gasification rather than drive it. In our view that remains the same today, a view endorsed by Air Products' selection of Westinghouse for the Tees Valley project."

There are a number of strands to this combination of technologies. Obviously from an environmental standpoint in using scrap [i.e. post re-cycled] carbon, the more net kilowatt-hours that can be produced from a given input the better – and with developing carbon taxes, lowest cost will follow efficiency. Commercially, as the market for feedstock becomes more competitive, the plant that produces the most value of output will be in the best position to secure its supplies.

Jones therefore describes the process as potentially playing an important role in the reduction of rubbish going to landfill, whilst making a significant contribution to the UK electricity supply.

He added, however, that there is another major benefit. "At the same time as creating clean hydrogen for the fuel cells, plants will generate a stream of capture-ready pure CO_2." Jones sees alkaline fuel cells as the ideal technology to efficiently produce low, or even negative, carbon electricity once storage technologies are established.

However, Jones believes low appetite for risk among funders means the first W2T-led project will combine plasma-assisted gasification with internal combustion engines (ICEs) to demonstrate the commercial viability of the model with proven technology. The project, known as the Midlands project, will be based on an 80k tonne model and will pave the way for projects using alkaline fuel cells.

Hydrogen fuel cells may be demonstrated on this project to prove the concept for funding purposes, opening the door to future sites delivering around 50 per cent more electricity to the grid. "As a business dedicated to achieving the most efficient conversion of the calorific value (CV) or energy of the feedstock delivered to the plant to busbar electricity supplied to the grid/private customer, the fuel cell offers around 60 per cent electrical conversion efficiency," said Jones.

Jones goes on to explain that projects and technologies must be seen in a strategic context. W2T has identified the 80 000-100 000 tonnes of feedstock waste-to-energy plant as commercially attractive, effective in terms of the proximity principle and also in the number of sites suitable for development.

"The issues, " says Jones, "are that large sites, such as Air Products' Tees Valley project, can use combined cycle gas turbines to convert syngas to electricity; [but] with lower volumes of gas, efficiency drops away. Alternative smaller scale technologies, such as ICEs, equally offer efficiency [percentage levels] in the mid-30s on syngas.

"The alkaline fuel cell on the other hand offers hydrogen to electricity efficiency of around 60 per cent and, as it is a modular technology, the scale of project is more determined by the economic scale of the balance-of-plant than by the generating equipment. Alkaline fuel cells will also maintain efficiency through fluctuation in the volume of feed gas, an important property when waste-to-energy plants are dealing with variable CV feedstock."

Following gasification the syngas will be cleaned – removal of particulates, acid gases, volatile metals etc. – with the cleaned gas passing to water gas shift and then separated in a pressure swing adsorption (PSA) unit. The hydrogen fraction feeds the cells, and the CO_2 can potentially be stored subject to national infrastructure developments.

The production of low carbon hydrogen at dispersed sites also offers the opportunity for diversion of gas to vehicle fuelling and other hydrogen economy destinations. W2T sees this type of plant as future proofed. "It is not simply tied to one output, i.e. electricity, but is producing a chemical building block so can adapt as economic circumstances change," noted Jones.

Jones therefore sees geography as an important component in site positioning. "As government grapples with the shift from a centralised to a decentralised power grid we believe waste has an important part to play. Waste-to-energy plants can be sited close to the multiplicity of 1-5 MW demand nodes across the UK, but especially near those in areas demanding high investment in marginal supply line capacity or at distribution grid pinch points, which threaten online supply integrity going forward."

In waste terms this means plant sizes of 50 000-80 000 tonnes, which means less concentrated traffic and fewer logistical impacts than for mega plants. Co-location around data processing centres, docks, airports, transport nodes, food processing centres, exhibition parks and industrial estates resonates with both the job and energy security debate.

All this is taking place at a time of change. In the last five years the market in waste has been transformed. On the supply side the landfill tax, though introduced in 1997, has at last raised landfill gate fees from £12 per tonne to £80 per tonne, with £100 in prospect by 2013.

This rising gate fee has diverted almost 45 million tonnes of material from landfill to other exit routes – currently recycling and anaerobic biochemical transformation in addition to the more traditional incineration. On the demand side, developing markets for recovered materials and uncertainties over the medium term supply capability of the current UK electricity infrastructure has encouraged risk investment in resource recovery. This change underpins W2T's plans – as gate fees have risen, interest in thermo-chemical conversion routes has expanded.

But other changes are also driving the market. Major waste generators are identifying the opportunity of taking control of this resource and its income opportunity, rather than simply viewing disposal as a cost to the business. And whilst the big six waste companies are reviewing this fundamental shift in handling routes, others are also moving into the space.

"Because no one company has exclusivity of the technological, logistical and end market opportunities, we are seeing the emergence of strategic partnering of the wastecos; partnerships involving, amongst others, civil engineering and finance specialists in changing combinations according to the needs of specific opportunities," commented Jones.

He also notes that those finance specialists have four simple needs to satisfy before money can flow: a feedstock supply agreement; an output off take agreement; appropriate site/planning and the right technology appropriate to the output profile.

"Only then does a project have legs as far as investors are concerned," Jones stated bluntly. Nevertheless, he also believes that W2T's close association with the commercial property sector places it in a position to evaluate the appropriateness of available tenants, feedstock and sites for the chosen technologies.

Jones is equally blunt about the involvement of the big utilities: "Not as interested as we believe they should be. It is easy to grasp their position though. Defensively they wish to protect economies of scale available from 2 GW platforms and the development issues for a 5 MW plant can be as complex as for a 2 GW one. Distributed systems are also more difficult to manage, although waste does have particular advantages in terms of on line 24/7 capability."

For these reasons Jones feels there may be more scope in the immediate future for energy supply companies and single wire deals i.e. direct supply to an end user. "The latter also have attractions in terms of reduced grid losses and therefore higher efficiencies, particularly when the alkaline fuel cell is taken into consideration."

Assessing the changing picture for the UK waste to energy market, Jones said: "No one really understands where the dynamic of the overall energy debate could take us. The impact of shifting transport to an electricity platform; gas grid capacity issues in shifting production from nuclear and coal to gas; population growth pressuring supplies to the southeast and then, climate change impacts, for example. What the need for air conditioning might produce in demand?"

Waste organics currently contribute around 2 GW of capacity from landfill gas and mass burn incineration without heat recovery. According to W2T in the future this energy recovery might expand to 4 GW electrical and 3 GW as heat. But to achieve this it believes plants will need to be high efficiency combined heat and power plants at a scale matching or contributing to local demand.

Jones summed up: "As a high efficiency system, plasma gasification combined with alkaline fuel cells offers a strong advantage and we look forward to driving that advantage home in the uncertainties of the coming years."

Integrating alkaline fuel cells with proven conversion technologies can increase electricity output by up to 130 per cent – from the same amount of feedstock