Hydrogen and electricity from plastic

A new process for converting waste – typically unrecyclable plastic and used tyres – into hydrogen and electricity has been independently assessed and is now in the commercialisation phase.
Junior Isles reports.

The environmental problem created by waste plastic has attracted a huge amount of mainstream publicity in recent times. At the same time there has been a growing interest in the potential of hydrogen as a fuel that could play a huge role in decarbonising the global economy.

During the last several months, UK company PowerHouse Energy Group has moved forward a proprietary technology, known as DMG®. It says the process is capable of eliminating waste, including plastic waste and used tyres with high levels of energy recovery, while producing hydrogen and electric power.

The ability to produce hydrogen to support the idea of a hydrogen economy is an attractive one, especially for the energy and transport sectors. While there has been much work on burning hydrogen in place of natural gas in gas engines or even gas turbines for power generation, it is its application in transport that could be a major driver. It is believed that using hydrogen to fuel transport could help reduce worldwide CO_2 emissions by more than 25 per cent. This would be a significant contribution in efforts to combat climate change.

Certainly, David Ryan, PowerHouse Energy's CEO believes in the feasibility of a hydrogen economy. "It can become a reality but in the UK, you would need national infrastructure investment on a scale not seen since the 1960s, when we moved away from town gas, which was similar to hydrogen.

"In Japan, however, it is being driven by fuel cell vehicles where there are already existing vehicles. Whereby in the UK you would struggle to find a buyer for 1 t/day of hydrogen, in Japan there would be many buyers. There is a market there… and Korea is almost as well established."

But the ability to produce hydrogen is only one part of the story. The more immediate impact, at least in the UK, may be the waste handling aspect of the process. Eliminating unrecyclable plastic and end of life tyres are two of the biggest challenges facing the waste management sector.

PowerHouse Energy's DMG (distributed Modular Gasification) technology is essentially a pyrolysis process. Gasification is carried out at around 1000°C with the help of an oxidising agent but without introducing any oxygen or air into the process. The operation takes place in a slight vacuum but although there is a little air in the chamber, the product is not being burned.

Ryan explained: "It's not like a fluidised bed where you are beginning the burn but you are starving it of oxygen. We are just gasifying it. So we are melting the product and boiling it so it becomes vapour. We then control several of the reactions in that vapour to produce hydrogen."

The temperature, oxidising agent and the residence time of the gases in the chamber are controlled to produce either a hydrogen-rich gas or a methane-rich gas. When looking to produce electricity, the methane content would be increased so it can be burned in a reciprocating gas engine.

Ryan commented: "Knowing the model of what's going on in the process and where the target operation points are is our IP [intellectual property], but what we are controlling are temperature, oxidising agent and residence time. The work we are doing on our demonstrator and lab equipment means we're building different operating curves for different plastics, different waste and our target syngas. We can fix the control point to give us a sweet-spot for either methane-rich gas or hydrogen."

According to Ryan, the technique is a far cheaper way of producing hydrogen than steam methane reformation, which is currently the only industrial scale technique for hydrogen production. "We are smaller scale, cheaper and smaller footprint than an SMR."

He also noted that its DMG has a smaller footprint and is more efficient than electrolysers.

"There is the argument that electrolysers can be run from renewable electricity. Yes that can work but only up to a point, as there is only so much renewable energy. But we don't see ourselves competing with electrolysers; we're more complementary. An electrolyser might be good for a petrol station application where there might be the occasional car coming through but an electrolyser for a fleet of buses would need a significant land-take and significant cost. Our land-take for that would be just over half an acre, maybe an acre."

The technology is also not aimed at power from waste applications that could be handled by other waste-to-energy technologies such as circulating fluidised bed boilers. "We are not going for large scale," said Ryan. "Typically many of the gasification processes are 40 000t/annum and upwards; they are centralised and are an incineration type technology. Circulating fluidised bed boilers also typically have a throughput of around 40 000-50 000 t/annum.

"We are not competing in that market; we are looking at industrial generators of waste such as plastics or tyres, etc., or those targeting the hydrogen itself. These could be major waste companies who do recycling but can find no route for their high calorific value plastic products, other than sending them to landfill."

PowerHouse Energy says the DMG could be commercial at a size as small as 15t/day, or 5000 t/annum, but would be more attractive at 25 t/day. The current vision is that once a number have been built and operated at 25 t/day, the size will be increased to 40 t/day (12 000 t/annum). According to Ryan, its DMG vessels could be "loaded on to the back of a lorry" and their small size would make them easier and faster to permit – taking in the order of months as opposed to years.

Installing a DMG could also offer waste companies a slightly different model. As Ryan explained, they could for example use it to dispose of their waste plastic and then use the hydrogen as fuel for their refuse collection lorries.

While the technology might be too early for the UK in terms of hydrogen, it is already attractive for markets like Japan.

"In terms of the hydrogen side of the technology, in the UK we could be a couple of years too early but if we were sat now in Tokyo, we are perfectly at the right time," said Ryan. "And in Japan there is a healthy gate fee for waste and a good price for hydrogen. Once we are into hydrogen generation from our product, the gate fee for the waste becomes less important."

Ryan: in Japan there is a healthy gate fee for waste and a good price for hydrogen

PowerHouse Energy has seen interest from Japan. Following successful in-house testing and gaining "Statement of Feasibility" from DNV GL, in November it received a formal invitation to engage in advanced commercial discussions with Toyota Tsusho Corporation ("Toyota Tsusho"), the industrial arm of Toyota. A deal could help Toyota Tsusho and Toyota fulfil a commitment to providing their fuel cell vehicles with at least two years of free hydrogen.

And as costs come down, DMG technology will become more attractive elsewhere. PowerHouse Energy is targeting equipment costs of less than £5 million ($6.6 million) for a 25 t/day unit and says this will fall to around £4 million as more units are rolled out. If the total cost for delivery and installation is £6 million, Ryan says it could deliver a 15 per cent return on investment for the project developer and £1 million a year in savings to the host through reductions in electricity cost and waste handling.

Just over a year ago PowerHouse Energy announced a site at Ellesmere Port and is waiting to submit planning permits. Submission, however, depends on securing a power purchase agreement. In the meantime, six other sites have been identified at which PowerHouse Energy is now undertaking application specific engineering activities. An announcement is expected at one of these sites, also in the Ellesmere Port area, shortly.

With Japan looking promising and discussions under way with potential hosts, Ryan is confident of the future. He concluded: "We are doing about one firm proposal a week – mostly in the UK, with one in four for overseas. For sure, if someone comes with a firm commercial arrangement, we're able to go anywhere."

DMG simplified flow diagram of the process and what could be produced from 1 t/day of hydrogen from a truck full of waste