FLYING ON PIG MANURE

For years, an American oil company has urged us to put a tiger in our petrol tank. It looks like it is time they change their slogan. Pig manure turns out to be an unsuspected feedstock for kerosene. Will we see pigs fly in a few years? Don’t hold your breath...

Socially and morally, the pressure is growing on airlines to do something about their CO₂-emissions. No wonder there is a growing interest in green and recycled fuels, such as frying fat and oil derived from algae and other feedstock. At the end of 2013 British Airways announced that it was planning to spend half a billion dollars on fuel from Greensky London. This company is building a plant in Thurrock, just east of London, to convert 575,000 tons of household waste into 50,000 tons of kerosene and another 50,000 tons of diesel and naphtha, a feedstock for the chemical industry. The plan is for the first hectolitres of fuel to be produced in 2017.

Pig manure as feedstock

The question is, can manure also be used? Dutch livestock produces about 70 million tons of manure annually. The vast majority is used to fertilize fields and meadows, but the surplus is growing because the rules for this use of manure as a fertilizer are becoming stricter. At present 5 million tons of excess manure, mainly from pigs, is being produced annually. If there is no outlet for this surplus, the amount of livestock will have to be reduced by law. Henri Elen, director of the Renovia Company would find it a shame if this thriving sector would disappear in the Netherlands. He thinks that manure should not be considered a problem substance, but a useful resource – even a feedstock for fuel – if it can be unlocked in an economically and environmentally responsible way. This is no simple task: a lot of projects to turn manure into energy have failed or can only survives on government subsidies.

Frans Houbraken, with water from reverse osmosis
Thin as water

The problem is that pig manure - a mixture of urine and dung - is very runny. Only three to five percent are dry matter, which makes transportation to refineries very uneconomical, as it is mostly water you transport. The first step therefore has to be the thickening of the slurry, preferably as short as possible from the farm where the manure is produced.

A company that has made this its specialty is Hobe Manure Processing in the village of Bergeijk. By adding flocculants to the watery manure, they can cream the solids off the surface. The - still very wet - dung is passed through a belt press where it is further squeezed between rollers, so eventually a semi-solid mass is obtained. This mass has a dry matter content of about thirty percent.

The concentrated manure is rich in phosphorus and also contains part of the nitrogen from the original manure, both of which can be used as fertilizer. The remaining liquid contains some nitrogen and all of the potassium. Reverse osmosis (RO), a technique also used to turn seawater into drinking water on board of ships, is used to concentrate the liquid. By pressing through a membrane - a molecular sieve - it is split into pure water and a saline liquid, the so-called RO-concentrate. Being rich in nitrogen and potassium it can be used as liquid manure.

Flying tennis ball

The concentrated manure from the belt press is still too wet to turn into fuel. However, its semi-solid state means it can be transported over longer distances in an economically feasible manner for further drying. Normally a belt dryer is used: a conveyor belt that is slowly moving the manure through a tunnel of hot air. To increase dry matter content from 30 to 70 per cent this way takes about 500 kilowatt-hour of heat per ton of manure, a costly business even if waste heat is used. Another, newer, technology is PAD or Pulverized Air Drying, developed by the Dutch company Biovalor. It works by removing moisture mechanically, like when you hit a wet tennis ball and the droplets fly off. In this case it is not a tennis ball but wet manure particles that lose their microscopic droplets of water. Not by hitting them, but instead by placing them in a strong airstream.

To generate an air stream to dry semi-solid pig manure from 30 to 70 percent dry matter you need about 150 kilowatt-hours of electricity per ton of manure. Despite running on electricity rather than waste heat, the PAD appears to be economically more attractive than the belt dryer. It is also better for the environment because the nitrogen in the manure stays entrapped instead of being released as smelly ammonia gas.
Gasification

There are several possibilities to turn this dried manure into fuel. One is gasification: burning it under oxygen-depletion conditions in presence of steam at high temperatures (3000 °C). Under these circumstances manure breaks down into atoms, which then rearrange themselves into carbon monoxide (CO), hydrogen (H₂) and carbon dioxide (CO₂). After removing carbon dioxide through a shift reaction the remaining gases CO and H₂ can be converted into kerosene, naphtha, and diesel by the so-called Fischer-Tropsch reaction.

The combination of technologies - gasification and Fischer-Tropsch - has been developed for this application by the US company Solena, but is in fact a classic process that has been used since the mid 19th century to produce town gas. During World War II it was used in Germany to convert coal into diesel and later the technology provided South Africa with liquid fuel from coal in the era of apartheid. Nowadays Shell uses a variety - GTL or gas-to-liquid - to convert natural gas into diesel.

Inspired by charcoal

Instead of gasification, though Renovia Company wants to use pyrolysis as the next step on the road from manure to fuel. Pyrolysis is a technique that has been used for ages to turn wood into charcoal. In our case manure is heated under a low-oxygen atmosphere at much lower temperatures than during gasification (about 500 °C). This turns the manure concentrate into a kind of charcoal or ‘biochar’ as it is called. Apart from the carbon it also contains almost all the phosphorus from the original manure. The biochar can be enriched with RO-concentrate, the salty liquid from the first drying step, which contains much of the nitrogen and potassium. This mixture of biochar and RO concentrate is perfect for improving agricultural land. It not only contains nutrients for the plant, but is also a source of bio-digestible carbon that, when added to the soil, stimulates humus formation. It also improves soil structure and water retention. As a former producer of peat for potting Renovia director Henri Elen knows how important it is to keep the soil healthy. Hence his choice for pyrolysis and the nutritious soil improver it produces.

Economically unfeasible

Apart from producing biochar, the pyrolysis of manure also yields oil and gas. The original idea was to turn this into aircraft fuel - kerosene. This would allow pig manure from the region to help Eindhoven Airport reach its sustainability goals by allowing a big reduction in fossil fuel use. A study by Liu Hui, a student at Avans University of Applied Sciences, showed that it is technically very difficult to get fuel out of pyrolysis oil due to its composition. A better option – technically speaking – is gasification of biochar at high temperatures and then converting the resulting mixture of CO and H₂ (“syngas”) into kerosene. Preliminary calculations, made by Hui Liu, showed that 1 million tons of pig manure would yield 4,000 tons of fuel after separation, drying, pyrolysis and gasification.
Although complicated the process would be technically feasible, thus confirming an earlier study by Siemaab Mahmood at the University of Applied Sciences in Amsterdam. However, Hui Liu also showed that the conversion for manure to fuel is not economical, because the cost per litre of fuel from manure is several times higher than the price of one litre of kerosene from crude. For now the focus of Renovia is therefore on converting one million tons of pig manure into enriched biochar as fertilizer and soil improver, rather than fuel. Given the problems of soil fertility in agriculture, that seems to be a healthy approach economically, ecologically as well as socially. And for the question of whether we will ever fly on pig poo? As said: don’t hold your breath.

The project ‘Flying on manure’ is one of the five business cases that is being developed as part of the Interreg IVb BioenNW project framework: ‘Delivering bio-energy to North West Europe’. Five regions (Paris, Birmingham, Aachen, Liege and Eindhoven) are cooperating to promote innovative technologies to process and add value to biomass residues. Each of the five regions has a Bio-Energy Support Centre. The city region of Eindhoven (SRE) serves as the Bio-Energy Support Centre in the Netherlands. Development of this business case is done in cooperation with the company Renovia (Overpelt, Belgium), Avans University of Applied Sciences in Breda and the University of Applied Sciences in Amsterdam, department of Aviation Management.