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Dear Readers,

on September 20, 2019, in over 160 countries and 3,000 cities, more than 1.4 million people demonstrated for greater climate protection. The core demands of the demonstrators included the increased expansion of renewable energies and more climate friendly agriculture. These demands indicate that concerns are not related to reaching individual sector targets, as has always been the case up to now in terms of policy, but instead, nothing other than a complete restructuring of our industry in Germany and in the world.

Although, in many previous discussions, biogas technology has been considered too expensive and complex, now it is finally clear what a unique symbiosis of climate protection, biodiversity, sustainable development, recycling and flexible energy production is possible. In the past ten years, the biogas industry has continued to specialize and is now a provider for a wide variety of environmental services.

Despite the current slump in plant construction in Germany due to the lack of political input, the industry continues to generate innovations. Even though manufacturers are currently earning money more easily abroad, the impressive innovative strength of science, the manufacturers and the plant operators continue to ensure significant progress. This issue of the Biogas Journal contains some examples of this from the areas of flexible energy production, fermented fertilizer production, agitator improvement, and so on.

The biogas industry is still in a phase of optimization, in which greater increases in the efficiency of plant technology and in emission protection must be implemented. Even if such retrofitting, some of which is very costly, significantly impacts the plants in the short term, these developments nevertheless make the plants ready for the future. The most current example in Germany is the nationwide introduction of SCR catalysts in order to reduce significantly the emissions of nitrogen oxides (NOx) from combined heat and power plants, while improving engine efficiency.

The biogas industry is preparing itself for the future in an impressive manner, and the industry is ready to make its contribution to meeting the upcoming challenges in the area of climate protection.

Enjoy reading this issue!

Yours sincerely,

Manuel Maciejczyk,
CEO, German Biogas Association
IMPRINT

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The Biogas Journal contains supplements of the companies SaM Power and UNION Instruments.
The University of Hohenheim and the University of Lisbon produce successful carbon dioxide filters from digestate. The objective is to increase the gas quality and the cost-effectiveness of biogas plants.

By Martina Bräsel (Dipl.-Ing. · Dipl. Journ.)

To obtain biogas of natural gas quality, the biogas must be filtered because it contains a relatively high amount of carbon dioxide, which decreases its calorific value. “Until now, we have often used activated carbon for processing”, explains Dr. Catalina Rodriguez Correa of the Department of Conversion Technologies of Biobased Resources at the University of Hohenheim. She is a scientist on the research team that succeeded in making an organically-based filter. The highlight is that they use digestate from biogas plants, which they convert into activated carbon. This carbon from digestate is outstanding for removing excess carbon dioxide from the biogas.

The idea for producing biofilters from digestate was developed in a joint project. Scientists from Portugal, Mexico, Colombia and Germany worked together to research how to transform carbon materials from various agricultural residues into more valuable products. This work gave rise to the idea for using digestate for the adsorption of biogas. “We wanted to make biogas plants more cost-effective”, explains Prof. Dr. Andrea Kruse, director of the Department of Conversion Technologies of Biobased Resources. “Digestate is an interesting source material for us because it has a high carbon content”, adds Rodriguez Correa; moreover they are abundant. The researchers from the University of Hohenheim in Stuttgart and the University of Lisbon (LAQV-Requimte, Network of Chemistry and Technology) then developed the organic filter together.

Hydrothermal carbonisation (HTC)

In the first step of the process, the digestate is carbonised to increase its carbon content. This produces pores and oxygen-containing groups. “Carbon dioxide gets caught in these, while methane slips through”, clarifies Rodriguez Correa. For this process, the scientists use the chemical carbonisation process of hydrothermal carbonisation (HTC). Rodriguez Correa explains why: “Another option would be pyrolysis, but then we would have to remove the water from the digestate in advance”, and that requires a lot of energy. In contrast, HTC is a “wet process” because the thermochemical transformation process takes place in water. “This way, we can use the moisture contained in the digestate as a reaction medium”, she reports.

During the process, in an aqueous suspension at temperatures between 180 to 250°C and increased pressure, the biomass is transformed into HTC coal (hydrochar). The biomass is also heated in a pressure vessel or autoclave. “To start, we determine the reaction parameters in small autoclaves that have a volume of 10 millilitres”, says Rodriguez Correa. Subsequently, the trials are repeated in larger autoclaves (250 ml). If the parameters are correct, it’s time to use the “Mini-Coal”. The small carbonizer has a volume of eight litres of fermented fertilizer. In the trials performed, the maximum pressure of the “pressure cooker” was 30 bar. “We varied the temperature (190 to 250°C), the pH value (five and seven) and the retention time (three and eight hours)”, explains Rodriguez Correa. The retention time depends strongly on the incoming material: “Digestate requires less time because it is already pre-digested”, adds the department director.

Overall, the temperature, followed by the retention time, had the strongest effect on the chemical composition and the thermal stability of the hydrochar, she continues. Changing the pH value, however, did not have a large impact. “After this step in the process, the material generated is rich in carbon”, reports the professor. In addition, it is hydrophobic; in other words, it “fears” water, so it is easier to dewater. The hydrochar produced has characteristics similar to lignite. The carbon of the source biomass is, for the most part, a component of the solid phase, but to some extent it is also dissolved in the processing water. Only a very low percentage of the carbon is released as CO₂ (< 5 percent).

Creating micro-pores through “activation”

In order to be able to use the HTC coal as an organic filter, it must be treated again. The process of “activation” creates fine pores in the coal. To do so, it is first pressed and dried. Then the pieces of coal are mixed with lye and heated again, but this time to
600 degrees Celsius. This additional heat treatment generates micro-pores.

Rodriguez Correa explains the principle behind it: “A potassium ion sits on the surface and right at that position, the material is gasified”; in this way, the ion functions as a small drill that creates a hole in the material. She goes on to clarify that “there are other methods, but this is the way we get the finest micro-pores”. They form the space in which the carbon dioxide from the biogas can be stored, she continues. “With this process, we can significantly increase the surface area of the hydrochar”.

As a result, the surfaces become considerably larger. Before activation, they cover between eight and fourteen square metres per gram. After treatment, the surfaces of the activated carbon ranged from 930 to 1,351 square metres per gram. The volume of the micro-pores is between 0.35 and 0.5 cubic metres per gram. “For biogas treatment it is also ideal that, following activation, the surface is alkaline because carbon dioxide is an acid”, explains the scientist. The oxygen-containing groups and the structure of the materials, which is similar to graphite after activation, are responsible for the alkaline character of the surface.

In the following experiments, it was shown that the digestate product is a very effective adsorbent for CO₂. Figure 1, “Selectivity”, shows the adsorption ratio for CO₂ and methane (CH₄). According to Dr. Rodriguez Correa, “It demonstrates not only that the activated carbon from digestate adsorbs more CO₂ than methane, but also that it is better than other materials.” “We tested conventional, very advanced filter materials”, she continues.

Figure 1 shows that the performance of monoliths from commercial activated carbon (violet dashed line) and the pellets from commercial activated carbon (red dot-dashed line) is significantly worse. In the course of the experiment, they filtered considerably less CO₂ out of the methane flow. “The coal from digestate adsorbs about two to two-and-a-half times more carbon dioxide than conventional activated carbons”, adds Prof. Dr. Kruse. Also tested were MOFs (metal organic frameworks). These structures function like a sieve at the molecular level. The coal from digestate was the clear winner here as well. The researchers were quite astonished.

“It demonstrates not only that the activated carbon from digestate adsorbs more CO₂ than methane, but also that it is better than other materials.”

Dr. Rodriguez Correa
Svenja Kloße, a student, during the activation of the digestate carbon. In this process, pieces of coal are mixed with lye and heated again, but this time to 600 degrees Celsius. This additional heat treatment generates micro-pores.

The figure shows that the activated carbon from digestate adsorbs nearly twice as much CO₂ than CH₄. “At high temperatures, the activated carbon from digestate adsorbs about four times as much carbon dioxide”, adds Andrea Kruse. “This means that the organic carbons from digestate perform significantly better than other filter materials”, says the department director in summary.

For use with which plants?
“The range of application areas is broad”, says Dr. Andrea Kruse. It’s important, though, that the composition of the substrate is almost completely consistent. For plants that ferment material from the organic waste bin, the composition varies too much in the course of the year. These fluctuations would be “difficult to handle in terms of the technical process”, she continues, so the digestate product would not always have the same, good quality. In addition, the digestate varies, depending on the substrate used.

The current challenge is to pelletize the coal because powders are not suitable for the pressure-transformation-adsorption process. For this reason, the researchers are now testing various binding agents to be able to make larger pellets. The medium requires “a certain consistency” in order to be processed in a column. “That’s not so easy because we have to make sure that the pores are not damaged during the pressing procedure”, reports the professor.

The system cannot be ordered from the University of Hohenheim. Industry partner HTCycle is supposed to take over the marketing at a later time. “We don’t sell any systems, but the rights belong to us”, says the department director. But things are not far enough along yet. In the next step, the process chain is supposed to be set up on the university’s biogas plant at a technical centre scale. It will process about 20 kilos of digestate. Currently, the department director is dealing with the financing, but she is optimistic: “We have always received funding for really good ideas”.

*Note: Further information and graphics can be found at: Evaluation of hydrothermal carbonization as a preliminary step for the production of functional materials from biogas digestate; in: Journal of Analytical and Applied Pyrolysis, Volume 124, 2017, S. 461–474 http://dx.doi.org/10.1016/j.jaap.2017.02.014*)

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New challenges in nutrient management

The legal requirements for organic fertiliser have become stricter. At some biogas operations, storage space is in short supply. Only limited fertilisation with fermentation products in the autumn is possible. This means that the land available for application is limited as well. What options do operators have to respond? Fermentation products are high quality fertilisers which can replace the expensive mineral fertilisers, the production of which is energy intensive.

By Thomas Gaul

At many biogas operations, the fermentation product storage filled up well again over the winter. With the end of the waiting period on 31 January, fertilisers that contain nitrogen can be applied with opportune soil conditions to supply crops with nutrients. But as a result of the German Fertilisation Ordinance, which took effect in 2017, things have become more complicated for farmers with a biogas plant. The key points are the upper limit of 170 kilogrammes (kg) of nitrogen per hectare and year, that now applies for all fermentation products. In addition, the storage space for fermentation products must suffice for six or nine months. Moreover, the results of a soil analysis that establishes the fertiliser requirements for nitrogen and phosphate must be submitted. Those who dispense fermentation products must also supply information about the nutrient contents and the source material of the farm fertiliser (analytical parameters or a table of guideline values). Now fertilisation planning requires a great deal of work accordingly.

Preparing nutrients

Peter Schünemann-Plag, a consultant at the Chamber of Agriculture for Lower Saxony, describes the crux of the matter: “There are too many nutrients and not enough storage space”. In some regions, application areas are scarce: “Often, plant managers underestimate how much space they really need. For one hectare of silage maize, I also need one hectare for application”. The consultant believes that building a new fermentation product storage container is the most expensive way to solve the solution. The up and coming idea is separation, says Schünemann-Plag. However,
A tank truck brings the fermented fertiliser to the edge of the field and from there it is pumped into the application vehicle.

A tank truck brings the fermented fertiliser to the edge of the field and from there it is pumped into the application vehicle.

the possibility of separating slurry makes more sense than separating fermentation products. The solids would then be more transportable and could also be used in agricultural regions where they would be fermented in biogas plants. To reduce the storage space required, high-performance, mobile separators operated by machinery rings and contractors are in operation. Investing in your own equipment, however, must be considered carefully: A screw press separator requires an investment of 40,000 to 50,000 euros and saves about 1,667 cubic metres of storage space.

To reduce the storage space needed, many biogas plant operators also dry the fermentation products. “At first, the focus was on receiving the bonus for combined heat and power generation, but now it’s really about vaporising the water”, says Schünemann-Plag. In his biogas working group, ten of the 24 biogas plants have installed drying equipment, and many of them are increasingly high-performance vacuum vaporisers, reports the consultant: “Many driers were put into operation for the first time just in this past year”.

But drying isn’t always the ideal solution. Because beforehand, operators must also consider what they will do with the dried fermentation residue. A disadvantage is the high heat requirement because, at most, one litre of water can be vaporised per kilowatt. If the entire fermentation residue of a 500 kW biogas plant is to be dried, using the heat in any other way is almost impossible – unless drying is done primarily in the summer months when there is no demand from other heat consumers.

Complete processing in Belgium and the Netherlands

Complete processing, as it is practised in areas with intensive animal husbandry in the Netherlands and Belgium, goes a step further. The water is pressed into the semi-permeable membranes of a reverse osmosis system. The water molecules penetrate the membranes and any contamination is left behind. The resulting water can be used for operational purposes or allowed to flow into receiving waters without any further treatment. Stephan Kühne of Agrikomp estimates that this process costs 3.20 euro-
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Fermenting product has proven itself as high-quality, natural fertilisers on crop farms. The nutrient cycle is closed, the humus content of the soil increases and, in any case, yields are stabilised. Reducing the use of mineral fertiliser also improves the climate footprint for crop cultivation.

Changing the substrate mix

If not much space is available, nutrient-rich substrates should be removed. This applies for dried chicken dung, for example, which shouldn’t be liquefied again in the biogas plant anyway in regions that have excess nutrients. And high-moisture substrates such as sugar beets should also be removed, despite their good characteristics for fermentation. When storage space is in short supply, highly calorific substrates such as grain or CCM is a good alternative. However, warns Schünemann-Plag, with these substrates you need to keep an eye on the price: “Are the substrates inexpensive enough with respect to the compensation that I receive in the end?”

Increasing the efficiency of the biogas process can also be a component of nutrient management. In this case, according to Schünemann-Plag, it is not about the application of trace elements and enzymes, but rather the substrate decomposition technology: “Because breakdown is quicker, I also have less substrate with a shorter retention time”. There is also potential in creating flexibility. With the new engines and a greater degree of efficiency, less substrate is used and the amount of fermentation product is reduced. Substrate savings of at least 10 percent are realistic, based on the consultant’s estimates.

Above all, operators should think about dealing with the surface water at the biogas plant differently. Successfully collecting this water separately and treating it can save valuable storage space for fermentation products. In the meantime there are several technical solutions available which are ready for practical application. The Biogas Journal has reported on these in previous issues.

Farm manager Christian Ludden taking soil samples to establish nutrient content at the beginning of February. He determined that maize and beets utilise the nitrogen in the fermented fertiliser the best.
Replacing mineral fertilisers with fermentation products

The Gutsgemeinschaft Lente farm has had good experiences with using fermentation products. The 300 hectare crop farm at the south-west edge of the city of Hanover is operated as a joint business by partner families v. Richthofen and v. Lente. Since 2006, a biogas plant has also been in operation with a output of 530 Kilowatt (kWel) which was expanded to 795 kWu by increasing flexibility. The substrate is almost exclusively maize, which is primarily cultivated on the operation’s own land. Before the maize is sown, fertilisation product has always been applied and immediately worked into the soil. But in Lente, this is now also done before planting sugar beets. In the heavy colluvial soils of the Calenberger region, this crop is traditionally an important part of the rotation.

“The beets and the maize utilise the nitrogen contained in the fermentation product the best”, according to Christian Ludden, who manages the farm. The initial fertilisation for wheat can also be applied at the beginning of February, but the degree of utilisation would only be half that for beets or maize. In addition, you have to wait for a night frost, he continues, because the heavy soils are sensitive to pressure and the application vehicles would leave deep ruts.

“For our soils, piping would be best”, says the farm manager. Then only a relatively light tractor with the application equipment would have to drive across the field. Currently, a contractor applies the fertilisation product. He uses special trucks with wide tires and a control system for the tire pressure. The fertilisation product is distributed with drag hoses.

Fermented fertiliser instead of urea for sugar beets

Previously only mineral fertilisers were applied before planting sugar beets; urea was used for many years. Now it is being replaced with fermentation product. And it’s quite successful because the yields are truly impressive. Record values were reached, with an average of 18.5 tonnes of sugar per hectare – and all this despite the drought last year.

But fertilising with fermentation product has a positive effect even in this case, says Christian Ludden: “Due to the organic fertiliser, the crops are simply more resistant”. There is just more water available to them. The only mineral fertiliser used is some potassium for the beets. In Lente, sugar beets follow wheat in the rotation, so an intercrop can be planted in between. Fermentation product is also applied before the intercrop is sown in late summer: “In terms of the amount, though, we’re legally limited to 60 kg N/ha”, explains the farm manager. “For us, that is equivalent to an application of 12 cubic metres per hectare”. Last year, the final cover crop was planted on 15 September. The crop was able to develop well by the time winter started. The warm autumn weather was certainly helpful here. But Christian Ludden expects a high nitrogen surplus from the wheat: “Since the last fertiliser application there has been practically no rain”. The amount permitted for autumn fertilisation is actually too low to expect abundant growth.

For this reason, considering the expected nitrogen surplus, restraint would be appropriate in terms of fertilising the 78 hectares of sugar beets and 57 hectares of maize planned for this year. At the beginning of February, Christian Ludden took soil samples from the fields in order to be certain. The fermentation products are also analysed two to three times a year, says Ludden: “At least once during spring and during summer”. There are, however, no large deviations here because the substrate input remains the same. Due to the high dry matter content of silage maize and the lack of rain in the past year, there is still enough room in the fermentation product storage area in Lente for the farm operators to be unconcerned about the spring fertilisation.

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The wastewater of about 1.5 million Berlin residents is treated at the Waßmannsdorf sewage treatment facility. Each day, around 180,000 cubic metres of wastewater travel through the capital’s extensive sewage network and arrive here where the Berliner Wasserbetriebe, the city’s water supply and wastewater disposal company, has been doing ground-breaking work in the recovery of phosphates from sludge for many years.

By Dierk Jensen

The black soup is bubbling mightily. Steam rises, obscuring the view. “We aerate the sludge constantly with oxygen”, explains Andreas Lengemann, looking into the reactor, which is open at the top. “We also add magnesium so that the phosphorus dissolves and, finally, crystallises”, he adds. The lead process technician for the Berliner Wasserbetriebe is standing on the staircase on the external wall of the recycling plant of the Waßmannsdorf sewage treatment facility. The plant is 15 metres high. It is located right outside the southern city limits of Berlin in the state of Brandenburg in the immediate vicinity of the Berlin-Schönefeld airport, as witnessed by the constant departure and landing of aircraft.

The idea for recycling this nutrient, which is both finite and essential, was generated more or less due to necessity, says Lengemann with regard to prior history. The sewage treatment facility, built in the mid-1990s, was designed such that binding metals would not be used in the processing of wastewater, but rather, organic precipitation. Development and patenting of a MAP method

These circumstances, however, resulted in significant problems as time went on because, at a pH value of exactly 7.2, the phosphate undergoes sudden and extreme precipitation; within a short period, it was deposited on all of the pipes at the facility and clogged them. “A catastrophe”, says the 55-year-old technician, remembering. This required a technical solution. For this reason, experiments and tests were carried out for years until the Berliner Wasserbetriebe had finally developed the MAP method with both the correct dosing and the corresponding plant technology and had submitted two patent applications. This rendered the clogged pipe problem obsolete. Furthermore, the wastewater specialists were now able to provide a fertiliser that returned phosphate into the cycle. Way back in 2008 it was already approved with regard to legal fertilizer requirements. The airy, spiral staircase affixed to the external wall leads back down from the impressive, bubbling surface of the recycling reactor. Right next to the reactor are large digesters that generate enough biogas to run five engines, each with an output of 1.2 megawatts.

Lengemann opens a gate, allowing a look into the inner workings located below the recycling reactor. Material is constantly streaming out of a downpipe. It looks like coarse-grained sand. “That is our long-term fertiliser”, says Lengemann. “It contains the nutrients magnesium-ammonium-phosphate, or MAP, which are bound in crystalline form”. The reactor, commissioned in 2010, produces up to three tonnes of MAP fertiliser per day, or about 500 tonnes per year.

Little demand from hobby gardeners

Although the media paid a great deal of attention to the sustainable fertiliser product in the past and Lengemann and his team won the GreenTec award in 2015 for their ground-breaking work, sales of the fertiliser recovered from sludge, particularly to hobby gardeners, have remained quite manageable. Just three to four tonnes – portioned into small packages – make it into beds and
balcony greenery. The rest – that is, the majority – is used by agricultural operations. However, because the fertiliser cannot be absorbed by the crops if it is not sufficiently worked into the soil, marketing it for commercial agriculture has hardly become easier in recent years. Just the opposite: the prices have dropped dramatically. For this reason, Lengemann is counting on new customers who appreciate the advantages of this fertiliser, which contains phosphates. He is hoping that conversations with Bioland, an organic farming association, will lead to new marketing partners so that the plant used for the phosphate recycling process, which cost about two million euros, will not have to operate with huge losses.

But for the Berlin sewage treatment facility, the recycling process has another positive side effect: Because, with regard to its chemistry, phosphate binds water well, removing it makes the subsequent dewatering of the sludge to a dry matter content of 28 percent significantly easier. That saves time and energy. About 200 tonnes of dewatered sludge are generated daily in the sewage treatment facility. Incidentally, rather than incinerating it locally, up to now it has been used as a fuel admixture at the lignite power plants in the Lausitz region. Specifically, it is added at ratio of 1 to 30:

The long-term fertiliser, which contains phosphates, is portioned into small packages and sold to private gardeners as Berliner Pflanze®, a play on words which means both “Berlin plant” and “Berlin native”. The Waßmannsdorf sewage treatment facility processes the wastewater of about 1.5 million residents of Berlin.
Andreas Lengemann (Dipl.-Ing.) inspects the long-term fertiliser produced at the Waßmannsdorf sewage treatment facility.

climate friendly. So at the latest, this practice will finally end with the fossil fuel phase-out in 2038.

Ten percent of the phosphorus is removed
The Sewage Sludge Ordinance adopted at the end of 2017 specifies high rates for phosphate recycling, starting in 2029 at the latest. The MAP separation method alone cannot achieve this level. “With our patented process we remove about ten percent of the phosphate from the sludge”, acknowledges Lengemann, “but no more than that”. For this reason, his strategy over the mid-term at the Waßmannsdorf sewage treatment facility is to construct the facility’s own incinerator in addition to the existing MAP plant in order to be able to recycle the majority of remaining portion of phosphorus from the ash. But recovering phosphorus from sludge ash is still – despite the experience of several research projects with various methods – uncharted technological territory. That’s why the entire wastewater sector is looking with great interest to see what’s happening right now in the Hamburg harbour. There, directly on the banks of the Elbe river, is the Köhlbrandhöft sewage treatment facility, operated by the city of Hamburg: a test plant for recovering phosphorus from ash has been running there since 2015.

Phosphorus from sludge ash
“Turning crap into gold” (“Aus Schiet Gold machen”) reads the enthusiastic title of a tabloid newspaper. Indeed, the trial operation seemed to go well. “The test operation confirmed technical feasibility and cost-effectiveness”, says Sabrina Schmalz of Hamburg Wasser; this means that it is the only known process on the market, up to now, that can recover phosphorus economically. Consequently, the partners of the test plant, Hamburg Wasser and the Remondis waste management company, established the Hamburger Phosphorrecyclinggesellschaft mbH in March 2018, which is currently building the first industrial-scale facility in the world for recovering phosphorus. As early as next year, according to Schmalz, the plant will be commissioned and recycle about 6,500 tonnes of ultrapure phosphoric acid from about 20,000 tonnes of sludge ash.

“The examples in Berlin and Hamburg demonstrate movement in a good direction”, says Prof. Dr. Ralf Otterpohl, who embraces the growing effort to return the finite nutrient phosphorus from municipal wastewater to the cycle. But even though the director of the Institute of Wastewater Management and Water Protection at the Hamburg University of Technology explicitly welcomes the Berlin method for MAP precipitation, he has a critical view of its costs with respect to a comparatively low rate of phosphate recovery: “It is indeed quite expensive”. Nevertheless, it is a significant start, although Otterpohl generally continues to believe that the separation of grey water (from showering, the kitchen, etc.) and black water “at the source of its generation” is still the most sustainable strategy, not least because it also enables the recovery of potassium and trace elements with minimal effort and cost.

But back at the site south of Berlin, the city’s grey and black water continue to flow, unseparated, into the Waßmannsdorf sewage treatment facility. Indeed, wastewater engineer Lengemann understands completely that his patented MAP method is not an all-in encompassing solution. Still, he is convinced by this recycling process, which has been functioning for years in Waßmannsdorf, minimizing the nutrient load of the fraction to be incinerated. “Moreover, interest in our method is growing”, he says, pleased.

Installing a reactor downstream of the fermenter or post-fermenter
Based on 30 years of operations experience, he is even of the opinion that the MAP method can definitely be applied in the biogas sector as well – specifically at those locations in regions where the nutrient input is already much too high. “Our reactor would have to be installed at the exit of the fermenter and then supplied with fermented slurry”, he says. The advantage is obvious: The nutrient load in the fermented fertiliser would be considerably reduced and, at the same time, the operator would be producing a fertiliser that can be transported and stored, can be sold commercially and that decreases the nutrient load in the region of origin. Whether this can be economically implemented or not is in doubt, considering current conditions and prices. Nevertheless, whatever role nutrient processing at biogas plants will play in the future in the context of the increasing strictness of water protection, the recovery of phosphates from municipal wastewater will provide noticeable support in the mid-term for reducing the import of phosphates to Germany for fertilizing purposes. And that’s a good thing. ◄
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Clean fuels from dirty water

Graforce, a Berlin-based company, is developing a process that uses controlled plasma discharges to produce hydrogen as well as source products for other environmentally friendly fuels from wastewater or fermentation residues.

By Dipl.-Journ. Wolfgang Rudolph

Wastewater from municipalities and industrial plants is an expensive environmental burden on society. And the load of urea, amino acids, nitrates and ammonium in the output of biogas plants is problematic if there is not enough space for nutrients to be used as crop fertilisers. For Dr. Jens Hanke, though, such liquids cannot be dirty enough to serve as input for the technology he has developed. “The greater the load dissolved in these liquids, the broader the options for shaping the end products”, says the founder and managing director of Graforce GmbH.

His business idea sounds a bit like magic. With the innovative Plasmalyzer process, hydrogen and other additional gases can be produced in a highly energy efficient manner. These gases are suitable for use in further processes to produce environmentally friendly fuels. In addition, the wastewater used in this method is purified during the same process and can be returned to the natural cycle. But this has nothing to do with magic, assures Hanke, a mathematician and robotics expert with a doctorate in the area of theoretical medicine. It rather has to do with the knowledge of natural science, and specifically, with the mechanisms of action in the dissolution and generation of chemical bonds.

A tamed thunderstorm in a water glass

Hanke illustrates how it works in the company’s development laboratory in the third storey of the Centre for Renewable Energy and Photovoltaics in Berlin-Adlershof. Here Graforce employees are working on modifying the Plasmalyzer process for various applications. In one of the rooms, Dr. Simon Schneider is looking through the viewing window of an apparatus about as large as a refrigerator: the so-called Plasmalyzer. In the apparatus is a glass container filled about halfway with water distilled during the sludge drying process. Due to the concentrated environmental poisons it contains, this water requires a particularly high degree of purification.

The conditions that exist behind the pane that offers a view into the Plasmalyzer are similar to those experienced millions of years ago on the Earth’s primordial oceans. Above the water’s surface, sequences of numerous lightning strikes occur with such rapidity that the human eye perceives them as a flickering plasma cloud above the bubbling liquid. “These are charge equalisation events similar to those that occur during a thunderstorm. We produce the lightning with a strong electric field of several thousand kilovolts”, explains the 34-year-old Hanke. Among other substances, the discharges release hydrogen. The hydrogen can be separated from the gas mixture with a membrane and can then be used as a green fuel for emission-free mobility, for example.
Hydrogen from the pollution load
But why go to all this effort? After all, conventional electrolysis can be used to produce hydrogen as well. In that process, as is generally known, electrodes are dipped into clear water and its conductivity is improved by adding acids or salts. But in order for hydrogen to form on the cathode and oxygen on the anode, electrical energy must be supplied at a rate greater than the bonding force between the hydrogen and oxygen atoms, which is 486 kilojoules (kJ) per mol.

In principle, this also applies for the lightning in the Plasmalyzer. But here is where the dirty water comes into play as an electrolyte. Because why use a lot of energy to break down this elixir of life into its components rather when the contaminants it contains, such as ammonium (NH₄⁺), also contain hydrogen? “The fact that the binding forces in these chemical bonds are weaker than those for water is helpful here. For example, a decomposition voltage of 90 kJ/mol is required to split NH₄⁺, i.e. less than one-fifth of the energy required to break up H₂O. The behaviour associated with the dissolution of other bonds with one or more hydrogen atoms is similar. We take advantage of that in the Plasmalyzer process”, says Hanke, describing the innovation’s approach.

The energy input can be controlled based on the strength of the electrical field generated by the plasma discharge so that only the chemical bonds of the waste load in the electrolyte are broken up, while the water molecules remain intact. Special membr-

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At the heart of the demonstration plant by Graforce, which functions automatically for the most part, is the Plasmalyzer, with which hydrogen is released.

The hydrogen released in the Plasmalyzer is mixed with biomethane in the demonstration plant. A mixture with raw biogas is also planned.
At the Plasmalyzer in the Graforce development laboratory, Dr. Simon Schneider monitors the
dissociation process used with the water distilled during the sludge drying process, which
contains pollutants, to obtain hydrogen.

With the tamed
lightning storm in the
Plasmalyzer, chemical
bonds in wastewater
can be broken up in
a targeted manner
to produce gases for
green fuels.

branes are used to sort and filter out the gases emitted
from the liquid. Nitrogen and oxygen are released back
into the atmosphere. The hydrogen is intercepted and
is available for use in various application areas, such as
in emission-free fuels or for energy storage.

Graforce calculates the production costs for hydrogen
in the Plasmalyzer at about three euros per kilogramme
(kg) (with an electricity price of eight cents per kilowatt
hour). This is considerably less expensive than a pro-
cess using freshwater electrolysis. In that case, costs
are currently six to eight euros per kg of hydrogen. If
renewable electricity is used, hydrogen production with
the Plasmalyzer process is climate neutral. Besides,
only purified water is left from the process.

Increasing the value of biogas with hydrogen
With the demonstration plant that was commissioned in
October of last year at company headquarters in Berlin-
Adlershof, Graforce wants to show that the Plasmalyzer
technology is ready for practical use. In the complex,
which is about the size of a covered bus stop and func-
tions automatically for the most part, hydrogen is ob-
tained by using the dissociation process on centrate wa-
ter and water distilled during the sludge drying process.
The Berliner Wasserbetriebe, a project partner and the
city’s water supply and wastewater disposal company,
provides the water. The PV modules at the building com-
xplex of the Centre for Renewable Energy and Photovolta-
ics supply some of the electricity required.
The hydrogen obtained is mixed directly with biome-
thane in the demonstration plant. The gas then contains
30 percent hydrogen by volume and 70 percent biome-
thane by volume. “If used as a fuel, this increases its
calorific value. The efficiency of gas engines improves
by six percent and during the incineration process,
in units which are classified as low-emission anyway,
considerably less nitrogen, CO₂ and hydrocarbons are
produced”, says Hanke, listing the advantages of the
gas mixture. In the future, the Berliner Wasserbetriebe
will use it to fuel some of the utility vehicles in its fleet.

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In the next step, Graforce wants to test a gas mixture including hydrogen and raw biogas. To avoid long transport routes, Hanke says that he could imagine establishing the Plasmalyzer technology, which can be expanded in cascade form, directly at a biogas plant. The liquid fraction of the pressed fermentation residues would be used as an electrolyte. The hydrogen obtained in this way could be mixed together with the raw biogas directly in the gas storage above the fermenter. Trials show that this stimulates the formation of additional methane. The calorific value of the biogas, Hanke continues, can then be increased, if necessary, by subsequent admixture of hydrogen to the point that the gas mixture can be used on site as a fuel in vehicles or agricultural machinery.

The Plasmalyzer process as a set of molecule building blocks

Initially, though, pilot plants are planned for the Waßmannsdorf and Schönerlinde sewage treatment facilities in Berlin. Here the focus is on coupling wastewater treatment and hydrogen production. According to Hanke, this possible combination has garnered interest among municipalities which, due to quick growth, are increasingly faced with disposal problems. Requests from New Delhi and Beijing demonstrate this trend. The people at Graforce are convinced that the Plasmalyzer technology opens up even more possibilities with regard to mobility and the provision of climate friendly energy. Because even carbon chains are broken up at 400 to 600 degrees in the lightning storm in the Plasmalyzer and, with the addition of electrons from other crashing molecules, new bonds are formed.

“We are currently working in cooperation with the Audi e-gas project on the targeted production of carbon dioxide and carbon monoxide by controlling the dissociation process used with wastewater in the Plasmalyzer. In the following process step, the carbon dioxide or monoxide reacts with hydrogen to form methane (CH₄) or synthetic fuels such as green kerosene”, says the managing director of Graforce, providing a look into the current developmental work.

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Produce electricity with flexibility and use 100 percent of the heat

From farmer to heat supplier: Biogas can be used not only to produce green electricity, but also to provide heat. Operators still do not take advantage of the option to supply large commercial and industrial heat consumers often enough. One example from the Weserbergland region demonstrates how it can work – along with flexible electricity production to boot.

By Thomas Gaul

If an industrial park expands toward a biogas plant or an agricultural business, operators usually react by worrying. The fear is that the new neighbours could take offence at the operation’s noises or odours. This, however, is not the case for Alexander Busse and his father, Wilhelm, from Höxter-Albaxen in the Weserbergland region. Because if the city expands the Höxter industrial park into the 70 hectare piece of cropland directly in front of the biogas plant operated by the Busse GbR, the new commercial enterprises mean more consumers for the heat produced by the biogas plant.

The plant already supplies a large fan manufacturer and three other businesses with heat. The heat is used completely, i.e. the businesses do not rely on heating oil or natural gas, so they are also reducing their carbon footprint. Father and son proceeded step by step with the expansion of energy production. The first action was to relocate the operation away from the crowded space in the village in 1999.

“You couldn’t run an agricultural operation here in town anymore”, says Alexander Busse. A new dairy barn was built outside of the village, directly on federal highway B64 and not very far from the Weser River. Along with the relocation, the original mix of production was specialised toward dairy cattle farming, and the external business was transferred to contractors and a neighbouring crop farmer.

A biogas plant instead of a barn expansion

Today 150 dairy cows are milked here by two milking robots. The plan was to expand the dairy barn to hold 300 cows along with five robots. But this plan was never implemented. Instead, in 2010 it was decided to invest in a biogas plant with 265 kilowatts (kW) of installed capacity. With their manure and the slurry, the cows supplied a majority of the substrate input. Manure also comes from other agricultural businesses in the area, some of which are operated part time. Due to the stricter legal provisions, these operations have absolutely no options for storing the manure according to the proper procedures. Like several others in the region, the plant was planned and built by the Kassel Machinery Ring.

In the following year, a satellite combined heat and power unit (CHP) was added with another 265 kW. The construction of the heating network began at the same time. It was initially designed for 400 kW. The first customer was the fan manufacturer. “The contact was made in the hallway at the offices of the building authority when I went to get a permit”, remembers Wilhelm Busse, “the company director was also there and said that we could indeed supply his factory with heat from our biogas plant”.

In 2014 things continued, step by step, with the permit for two additional 265 kW CHPs at the satellite location and at the plant itself. And the plant was expanded by another 265 kW as well. Slap silos and a larger fer-
The two operators: Wilhelm (left) and Alexander Busse.

Maximum flexibility
After the German Renewable Energy Act (EEG) at that time allowed the plant operators the option to create flexibility, the Busses also started thinking in this direction. “The push forward came during an informational event of the ‘KWK kommt’ campaign [“Combined heat and power generation is coming”] in February 2016 in Hanover”, says Wilhelm Busse. “On the way home we discussed it and then decided to build the maximum-sized superstructure”. The goal of creating flexibility was clear to them. Alexander Busse says: “Our goal was to achieve the highest rated output, which we had not previously done”.

Both of the Busses fully support the idea of creating flexibility: “This is the only way to justify a relatively expensive source of energy like biogas”, says Alexander Busse. “This can also be explained to the public: flexible electricity production that meets their needs”. Flexibility was created at both the plant itself and at the satellite location, each with a rated output of 480 kW. The biogas CHP is not supposed to run 24 hours a day. The farmer and plant operator see such flexibility as an “investment in the future”. At the time the decision regarding flexibility was made, the plant was scheduled to receive compensation according to the Renewable Energy Sources Act (EEG) for 14 more years. The Busse GbR invested about four million euros in creating flexibility for their plant and the heating network. This includes two large MTu engines, one at the plant and one at the satellite location, each rated at 1,870 kW, in addition to two heat accumulators with a volume of 300 cubic metres.
The large MTU engine has an electrical output of 1,870 kW.

**Larger gas tank capacity planned**

“The largest containers that can be transported on the road in one piece are the horizontal ones”, reports Alexander Busse: “We manage quite well with this size. They can buffer the results of one day of heat production”. A larger gas tank would allow for more flexibility. “That’s also part of our plan”. But according to Alexander Busse, the permit process for the intended location next to the biogas plant has stalled. Still, the heating network is now designed for a capacity of 2.2 megawatt hours. Because the old transformers were not sufficient for this load, two new transformer stations were added in the move toward flexibility. “However, the connection to the electricity grid does not pose a problem here because there is a transformer station nearby”, says Alexander Busse. The energy provider has a switching substation directly next to the satellite location. The Busses were able to install the heat distributors themselves. The line to the satellite location, where the gas pipe also runs to the satellite CHP, is 600 metres long; the circuit through the industrial park is longer: two kilometres. “Our advantage was that we can use primarily our own property for the line”, emphasises Wilhelm Busse. But there wouldn’t have been a problem in this respect with the company owners in the industrial park anyway because the pipe work was finished quickly. The operators are hoping that policymakers understand the context of “green heat” from biogas because it offers an option for doing something quickly and effectively to protect the climate. The necessary transition in heat production could be advanced considerably if CO₂ were more expensive and the advantages of biogas for private and commercial heat consumers become clear.

**Customised heat supply contracts**

“In creating flexibility, we only wanted to supply heat”, says Wilhelm Busse. The plant expansion and the efficient and complete use of the heat were only possible because creating flexibility supplied the incentive. After a year of flexible operation, the operator has achieved a positive result: a profit of 510,000 euros. “But we shifted the profits”, says Alexander Busse: “We had expected about 110,000 to 120,000 euros in revenue from the sale of control energy. Due to the mixed-price procedure, both the positive and the negative secondary balancing power were completely eliminated”. Although the prices on the EPEX spot market show a tendency to rise, the fluctuations are still too slight, Busse says. The profit of about 12,000 euros per quarter and location, however, applies as planned, in addition to 50,000 euros from the sale of heat in the first year. When structuring the heat supply contracts, negotiations must be made with each individual customers, emphasises Alexander Busse. Accordingly, different prices apply for heat as well. On average, the price is eight euro cents per kilowatt hour.

The commercial enterprises that connect to the heating network of the Busses rely completely on the heat produced by biogas. But at the location of the first heat customer, the fan manufacturer, there was still an old heating system. In addition to the heat used for the rooms of the business, process heat will also soon be supplied for the paint shop. If heat consumption continues to increase, a gas-fired CHP is being considered. While there would definitely be extra heat capacity during summer operation, in the winter, heat is needed for the fermenters. More flexibility has also had a positive impact on the maintenance costs. Now the large engines run just twice a day, generally from 6 a.m. to 12 p.m. and from 4 p.m. to 10 p.m. The feed supply is also adjusted because on the weekend, only half of the output is required.
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**Well-agitated is half fermented**

In 2019, the Steverding company, located in Stadthohn in the German state of North Rhine-Westphalia, can look back on 25 successful years of development. In addition to the construction special machines, manufacturing components for biogas plants is one of the important pillars supporting the business.

By Martin Bensmann (Dipl.-Ing. agr. (FH))

Energetic paddling is going on in the fermenter tanks of many biogas plants. But that doesn’t mean that someone is traveling over the fermentation substrate in a boat. Instead, we’re referring to paddle stirrers that mix the fermenting mass thoroughly and evenly. These stirrers have a pipe (shaft) that is mounted horizontally or vertically. Agitator arms, to which paddles are attached, are screwed onto the shaft at specific distances. They are operated by external electrical motors.

“At the end of the 1990s we started to manufacture the first paddle stirrers for the Austrian market. They were called Hydromixers because they were operated hydraulically. Biogas plant operators were also the customers at that time. In addition to the agitators, we also equipped technical containers for biogas plants”, remembers Stefan Steverding, founder and director of the company.

**Initially a one-man start-up**

In 1994, he became self-employed as a master in machine design and construction. At that time, it was a one-man shop. In addition to general machine engineering, the young entrepreneur also did work in the production of conveyor technology and in special machine construction for the wood and plastics processing industry. In 1999, a new production site was built and the number of employees increased to eight. After the paddle stirrers proved successful in Austrian biogas plants, at the beginning of the 2000s customers in Germany also started to take notice of the plant components from the Münsterland region. “That was when we began to expand the product family more and more. And as fermenter tanks got larger and larger, so did the agitators. The largest agitator in a stirred-tank fermenter is 27 metres long with a diameter of four metres. We installed a 30 by 6 metre in a plug-flow fermenter”, reports Steverding enthusiastically.

In 2003, the Steverding Rührwerkstechnik GmbH was established, where the equipment development, production and sales have taken place ever since. In 2004, the company started a close cooperation with the University of Münster at the Burgsteinfurt location. The cooperation involves a scientific investigation of the design of stirrer geometries and testing of flow simulations. Steverding can also examine agitator behaviour in a technical centre at the company’s headquarters. For example, gear loading can be tested on a special performance test bench. The torque applied to the paddles can be checked on another test bench. In a trial container with a scale of 1:10, a wide variety of stirrer geometries and their flow behaviour can be tested.
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**Awards-winning technology**

Working hard is worthwhile: in 2009 Steverding received the major prize for innovation among mid-sized businesses at the state level in North Rhine-Westphalia. The Prof. Adalbert Seifriz prize for technology transfer between the trades and the university followed in 2013. “Right now we’re working on sensor technology that is supposed to recognise when the agitators have to be working and when they don’t”, says Steverding, looking toward the future. And because innovations also have to be protected, a patent application was filed for the Spiralo agitator.

More than 3,000 of the standard agitators have already been installed. Plant operators in Great Britain, France, Greece, Turkey, Latvia, Estonia, China, Chile, Canada and the Ukraine recognise the value of the workmanship practised in Stadtlohn. Seventy agitators must be delivered to China alone for two projects. There are already requests for more than 210 agitators for the coming year.

In Germany (with still only ten percent of turnover) the technology is currently being installed primarily in existing plants that are in the process of refitting and have to replace worn out agitators. But the plant operators who are using new fermentation substrates that contain lots of fibre components are also resorting to paddle agitators.

Stefan Steverding (right), Managing Director of the company, and employee Markus Graute in the assembly hall for paddle stirrers.
Beyond agriculture, the chemical industry is buying the agitators made by Steverding. Most of the orders are realised by planning departments and biogas plant manufacturers and to a lesser extent by direct, end customer business.

To China by train
Foreign companies that install the agitators on site receive specific training at the Steverding company. Special support centre partners take care of the spare part supply abroad. “The freight departs by train starting in Hamburg; soon, we’ll start from Duisburg as well. You could say that we’re traveling down the new Silk Road. The train needs 16 days to arrive in China, so it is significantly quicker than a ship”, emphasises Steverding. Because the agitators rotate very slowly, wear is very low and durability high. According to Steverding, the paddles are subject to virtually no wear at all. Only the bearings and the gear unit have to be replaced at some point, depending on use.

“We adapt the agitators specifically to different container geometries”, affirms Stefan Steverding, adding, “Even with high total solid content in the fermentation substrate, our agitators have no problems”. With this technology, sinking and floating layers do not even occur. The agitators that operate horizontally have an electrical connected load of 10 to 30 kilowatts; those that operate vertically up to 60 kilowatts.

“Agitators in containers with changing fill levels are fitted with a special ceramic-polymer coating. It protects the steel from corrosion in the gas space. In addition to the agitators that operate horizontally and vertically, we have recently also started offering agitators that extend diagonally into the fermenter tank”, explains Markus Graute, who works in the technology and sales area. And so that no fermentation substrate can penetrate to the outside, the company has developed special sealing systems that are installed in the agitators to prevent even media with a high fibre or sand content from escaping. They add to the security provided by the mechanical seals. The space between the container wall and the agitator is sealed with an annular gap seal.

In a new trend, small paddle stirrers are used in mashing tanks to mix in loose straw, for example. The small paddlers can stir mixtures with a dry matter content of up to 20 percent to create homogeneous mixtures without encountering any problems. If the fermentation of waste products really gets going in Germany and internationally, then the jobs at Steverding will be secure for a long time to come.

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France has set ambitious goals: As soon as 2023, the biomethane feed-in is supposed to increase to six terawatt hours (TWh) annually. Up to now, biomethane has been used primarily in the traffic sector. But the heat market is a promising alternative; over 40 percent of households in France are heated with natural gas. However, an investigation based on interviews shows that, in contrast to Germany, private end consumers still know very little about biogas and biomethane products.

By Prof. Dr. Carsten Herbes

In contrast to Germany in the past, France is planning to use primarily biogas from residual and waste materials to reach this goal. At events, the French contingent often notes explicitly that, in view of the experiences in Germany, France is consciously choosing another path. There are now around 800 biogas plants in operation in France; according to information from grid operator GRDF, at least 80 of them process biogas to natural gas quality and supply the biomethane to the gas grid (maximum annual capacity: about 1.3 TWh as of February 2019).
Biomethane feed-in in France: Actual situation and planned expansions as well as new construction required

This means that in order to reach the target of an annual feed-in of six TWh by 2023, based on the figures from 2018 and an average maximum feed-in total of 16 gigawatt hours (GWh) per plant, at least 300 new biomethane feed-in plants must be built by 2023. This is an extremely ambitious goal when you consider that in Germany, after a much longer development period and, at times, very positive economic conditions, there are currently just about 200 plants in operation with a total feed-in of approximately nine TWh.

In an additional complication, in the newest version of the “Programmation pluriannuelle de l’énergie”, the French government has planned a target compensation of 6.7 euro cents per kilowatt hour (kWh) (2023) and 6.0 euro cents per kWh (2028), which is considerably lower than the prices paid currently. If these prices are not reached, the feed-in totals will be reduced. The maximum planned compensation is 8.7 euro cents per kWh (2023) and 8.0 euro cents per kWh (2028). In the mid-term, however, in addition to classic biogas plants, plants that use thermochemical gasification to produce renewable gas will also likely play a role in France; some demonstration projects are already underway there.

Today, the traffic sector is more interesting than the heat market

Where is the biomethane that is fed in used? Currently it is used primarily in the traffic sector, which also has to do with the fact that, due to legal provisions, this type of utilisation is financially more attractive to the feed-in plants than selling it on the heat market. But in the future, the heat market could become more interesting because the market penetration in France of natural gas vehicles, including heavy-duty vehicles, is also quite low at 0.2 percent. Use of natural gas vehicles is increasing only at the municipality level for bus fleets and refuse trucks.

In French households, consciousness of the environmental effects of energy consumption is now rising as well. In addition to the market for green electricity, which offers about 40 rates throughout the country, the first biomethane-based green gas rates have been developed. In 2016 the market did not yet offer biomethane-based rates, but in 2017 the first rate was
established and by August 2018 there were already three. Now a resident of Paris can choose from four different rates, although they all originate from one provider and differ only with regard to production site and price. Another three rates from other providers are designated “gaz vert”, or green gas, but they are natural gas rates with CO₂ compensation. There are some areas of the country where no green gas rates are offered.

Overall, the French gas market is more strongly concentrated on a few providers than in other European countries, and consumers are less likely to change providers. But precisely these circumstances could be an argument for biomethane-based rates. Gas providers can use this ecological alternative to differentiate themselves from their competitors and persuade consumers to switch.

The survey
But what do consumers think of biomethane-based gas rates? The HFWU Nürtingen-Geislingen University carried out an investigation in France based on this question. In detailed, qualitative interviews, twenty private French consumers were asked about their knowledge of and opinions about biogas in general and biomethane-based gas rates in particular.

Knowledge regarding the subject of biogas was quite low. Four of the twenty people surveyed had never heard the term “biogas” or the word “biomethane” before. Most of the others said that they had only very limited knowledge about the subject; the same applied with regard to renewable energies in general. Among the advantages of biogas mentioned were not only the reduction of negative environmental effects and the efficient use of waste, but also less dependency on foreign suppliers.

The primary disadvantage mentioned was the cultivation of biomass for biogas production, to some extent as the “dinner plate or fuel tank” argument similar in Germany. But removing slurry and other organic fertilisers from agricultural use was also criticised, although the nutrients would actually still be available to farmers in the form of fermentation product; therefore, this perception was false. In addition, some people assumed that the existing infrastructure, e.g. heating systems based on natural gas, could no longer be used in private homes; this also does not match up with reality. Presumptions about price varied: While some of those surveyed feared higher prices, others expected a price reduction if the biogas were produced from waste.

Desired characteristics
A rejection of the idea of growing plants to produce energy, which was already clearly one of the perceived disadvantages, also came up in the context of the desired characteristics of biomethane-based rates. Residual and waste materials from agricultural operations are the most popular substrates, followed closely by organic household waste. Far behind, however, are catch crops, and energy crops were in last place. Other positive characteristics, in the opinion of most of those surveyed, were eco-labels and local production of biomethane, the latter primarily to minimise the length of transport routes, but also because the plants could be smaller if they were located at various sites in a decentralised fashion. With regard to the question about the type of supplier they would most prefer to purchase biomethane from, none of the providers was clearly the best. But the former monopoly Gaz de France, now Engie, received positive comments. Although Engie allegedly lacks ecological motivation, those surveyed appreciated the safety and professionalism of the large provider.

Consumer readiness for biomethane-based gas rates
At the end of the interview, participants were asked about a specific rate offer: a product by Engie with a proportion of 10 percent biomethane from agricultural residues and waste produced in the home region of those surveyed. Five participants would not pay a higher price than the rate for pure natural gas (without a biomethane component). Eleven would accept an additional charge of up to ten percent; only four would pay even more. About half of those surveyed, regardless of their willingness to pay extra, were surprised that a rate with ten percent biomethane would cost more than a regular natural gas rate. To some...
extent, the participants found the higher price to be illogical. Why is research even being done on biomethane if, in the end, it will be more expensive than natural gas? As an alternative to the biomethane rate, a pure natural gas rate with compensation for CO₂ emissions based on the devaluation of corresponding emissions certificates was presented. Most of the participants rejected this alternative, preferring a biomethane-based rate instead. The idea that companies could buy an option to emit more CO₂ by purchasing pollution rights was repudiated outright by many of those surveyed, with some using quite dramatic language:

“No, but I don’t like the principle of buying emission rights because the large companies buy them all the time and then go unpunished as they produce more [emissions] than others. No!” (Interview 16)

“If that’s how it is, then I’m sorry, but that’s an complete mistake. Then you’re paying for polluting. That is unacceptable”. (Interview 19)

Overall, though, it seemed difficult for the French consumers surveyed to understand the mechanism of emissions certificate trading and devaluation, and they expressed their uncertainty accordingly. In practise, the question posed would be whether or not, in the context of the scarce information on the providers’ websites, consumers can at all understand the difference between biomethane-based green gas products and green gas products based on 100 percent natural gas with CO₂ compensation. The Selectra portal, however, does provide comparisons that clearly show which rates include biomethane and which are based on a compensation mechanism.

Conclusion: France has ambitious goals for expanding the feed-in of biomethane which, given the current state of development and in view of the planned reduction in compensation, seem difficult to achieve at best. If they want to develop the heat market and reach private households in addition to the traffic sector, which is now the dominant player in the utilisation of biomethane, much remains to be done in terms of communications. This is a task not only for the providers’ marketing departments, but it should also be bolstered by government initiatives.


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From the Allgäu region: biogas technology for the world

A conversation with Frank Paulmichl, managing director of Fritz Paulmichl GmbH, a company located in southern Germany which manufactures separators, stirring equipment and pumps, about their biogas work in Argentina.

Interviewer: Martin Bensmann (Dipl.-Ing. agr. (FH))

Biogas Journal: Mr. Paulmichl, since when have you been involved in the area of biogas technology in South America and how did you gain a foothold in Argentina? You must have a sales office in Argentina, right?

Frank Paulmichl: Six years ago we made initial contacts, but the project was not carried out with us. Three years later, we were requested by the project to implement retrofitting measures because the plant didn’t work. Four years ago, at the Agritechnica trade fair in Hanover, we met two young engineers who, though they had little experience with biogas, did see its potential. We visited plants in Germany with the two engineers and provided them with important information about the details. That generated two projects, which were also implemented with us. In this way, we expanded our contacts.

In 2018, the two young engineers organised an informational event in Buenos Aires. I gave a talk there. This event generated a great deal of interest and resulted in more interesting contacts. On a trip taken by a delegation of the German Chambers of Commerce Abroad, we were invited to the Agricultural Ministry together with representatives of the German Embassy. The Secretary of State also came along. Import relief, which already exists for photovoltaics, etc., was addressed.

More contacts were made at these meetings and in Cordoba as well, where we were also asked to assist with retrofitting plants. We modified these plants by using our stirring equipment to adapt them to the specific circumstances. A technician from our company and I were personally on site to do the work and installation and monitor it. At this time, we also trained the operators and their employees with regard to handling the technology. And this, in turn, generated more very interesting contacts and projects. Sales are organised from Germany, but local partners provide us with the respective information. These local partnerships are not organised in offices. They are based on trust and friendly cooperation.

Biogas Journal: Which plant components from your company are in demand in Argentina and how many biogas plants have you now equipped?

Frank Paulmichl: The main emphasis is on our large paddle agitators and the corresponding panorama inspection glasses. As a result, demand for our pump and separation technology also continues to increase. The advantage of our components is the customised adaptation for the special circumstances and requirements in Argentina. Up to now we have built ten plants and another ten are currently in the project planning phase.

Biogas Journal: Do you manufacture components in South America or do you supply them from Germany? If you export them from Germany, what are the logistics of transport? How are the orders financially secured?

Frank Paulmichl: We manufacture the components in Germany and deliver them to South America. We take care of the logistics for customs clearance and transport ourselves with regional transport and logistics partners. Our company has this experience due to many global projects. Business transactions like these are secured with the local bank via documentary business and guarantees.

Biogas Journal: Who are your customers in Argentina? Are they involved in agriculture or are they industrial operations or is it the disposal business?

Frank Paulmichl: Our customers are mainly agricultural operations and agricultural production cooperatives (e.g. slaughterhouses and the disposal business for slaughterhouse waste). Industrial operations are not yet among our current customers.

Biogas Journal: Are the plants operating in Argentina generally waste plants or plants that process agricultural residues? Can you tell us approximately how many biogas plants are in operation in Argentina?

Frank Paulmichl: Both types of plants are in operation, but the agricultural type of plant is clearly in the majority. At the end of 2016 there were 120 biogas plants in Argentina. Unfortunately, no current figures are available.

Biogas Journal: How large are the typical biogas plants in Argentina?

Frank Paulmichl: Two to three megawatts. Currently, all of the gas is converted to electricity. This conversion supports grid stability; previously, it was quite unstable.
Biogas Journal: Are there specific criteria for selecting the vessel material?
Frank Paulmichl: Yes, there are criteria for that. Primarily due to the size of the country, sometimes long distances must be travelled to reach the concrete plants or there are no appropriate transport vehicles. In such cases, stainless steel vessels are built.

Biogas Journal: How great is the potential of biogas in Argentina and what does the legal framework look like?
Frank Paulmichl: The potential is huge due to the very large livestock farming business in Argentina. Currently, we find the legal framework okay for us. However, we always have to keep an eye on political developments and the currency situation. In 2015, 1.9 percent of Argentina’s energy was renewable and by 2025, it wants to have 20 percent renewable. From today’s perspective, that’s 10 gigawatts within the next 10 years or about 650 projects.

Biogas Journal: How does the order situation in Argentina look for you in 2019 and 2020? What percentage of your turnover consists of business in Argentina or overall exports?
Frank Paulmichl: For 2019, we are overbooked with orders, and for 2020 it appears that it will be just the same. The turnover for Argentina is about 1.5 million euros, and for 2020 we are expecting at least the same amount.

Biogas Journal: In which other foreign markets are your products in demand?
Frank Paulmichl: We supply customers all over Europe. Globally, in addition to Argentina, we deliver our products to Brazil, Kenya, the Philippines, the United Arab Emirates, Panama, New Zealand, North America, China, Malaysia and India, for example.

Biogas Journal: What are the greatest challenges or obstacles for biogas plant construction in Argentina or for German component suppliers?
Frank Paulmichl: The greatest challenges are, on one hand, the political developments in Argentina, and on the other hand, adapting the components for the circumstances and requirements in Argentina. Those are obstacles because they require lots of flexibility. Political development: In 2018, inflation in Argentina was about 35 percent, and in 2014, they underwent the second state bankruptcy since 2001. Therefore, political developments must be closely watched. Adaptation for the requirements in Argentina: Due to sand input, the substrates are significantly more abrasive. The size of the plants and the related substrate to be stirred becomes even more viscous due to drought, so the stirring equipment has to be adapted. We do this by changing the size of the stirring paddles and adjusting the speed. Likewise, there are other advantageous adaptations, but for reasons of competition I cannot provide any further explanation.

Biogas Journal: Mr. Paulmichl, thank you for this conversation!

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Biogas plant in Posse in the province of Cordoba in the central of Argentina.
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