On the road to brewing self-sufficiency

Dr. Karl Glas and his working group are experts in water management in breweries and food producing companies. From designing the chemical and biological properties of water to solving complex purity issues, they are searching for the optimization potential inherent to these companies and their processing operations. Currently, their aim is to help small and medium-sized breweries to clean their wastewater self-sufficiently with the aid of microbial fuel cells. The fall of 2019 saw the first pilot system in the brewery and beverage industry in the whole of Germany go into operation at a major German brewery.

Link
www.molekulare-sensorik.de/index.php?id=55

Graphics: ediundsepp

In the face of rising costs, the pressure on breweries to use power and water more efficiently is also on the rise and with it interest in innovative solutions.

Water is not just water. There is probably no-one who knows that better than Karl Glas, Head of the Water Technology working group (AGW) at the Chair for Food Chemistry and Molecular Sensors at TUM in Freising. Whether as a raw material for production or as process water and wastewater in the food and beverage industry, water can exhibit a large variety of properties.

Which water is it to be?

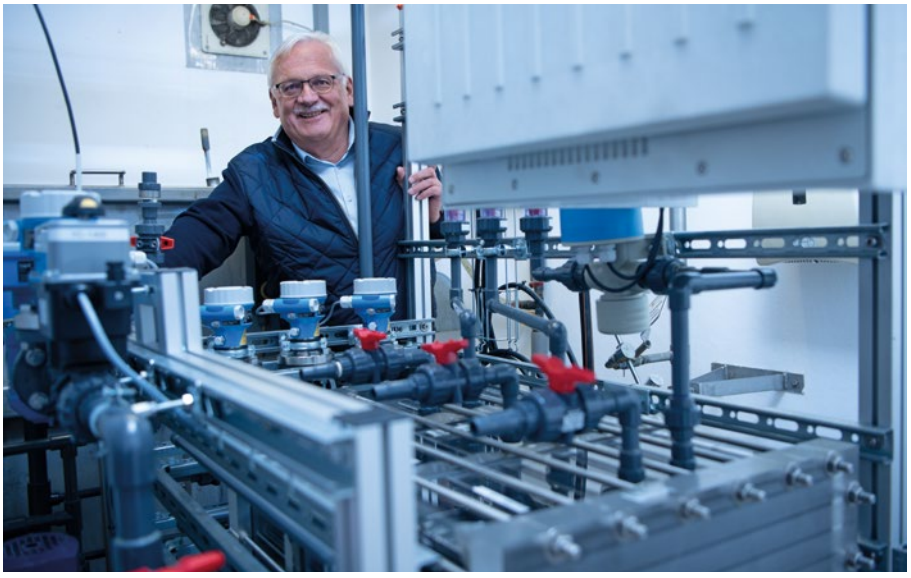
"We are talking about water design," Glas says and asks: "How can I design my water in such a way that it is pristinely clean or precisely matches the requirements of a certain application? That is the core element of our work. In the food and beverage industry, the water must be sterile and other substances already in the water or introduced into the water during operations such as pesticides, lime, copper, disinfectants, etc. must be removed." In this context, the AGW is researching innovative solutions in sensor technology, filtration and disinfection. Process water in the brewing industry, the specialist area of Karl Glas, occurs in various physical states in the plant: as hot water, cold water or steam – in every state, it must be of drinking water quality and be processed accordingly.

In addition, water is an important factor when it comes to the cost-effectiveness of facilities and their impact on the environment. “Industry still has a lot of opportunities to save H_2O and CO_2,” Glas emphasizes. Born in Augsburg, the man is steeped in practical experience. About himself and water, he says: “Actually, I did study brewing but I’m not your typical brewer, the kind you maybe imagine dressed in Lederhosen with a beer in one hand. Water as such is more important to me. Water is exciting because it’s scientific, technical, political and cultural. Water is always interesting, and the chemistry of water is no easy matter – thank goodness, otherwise we’d have nothing to research!”

“Industry still has a lot of opportunities to save H_2O and CO_2.” *Karl Glas*

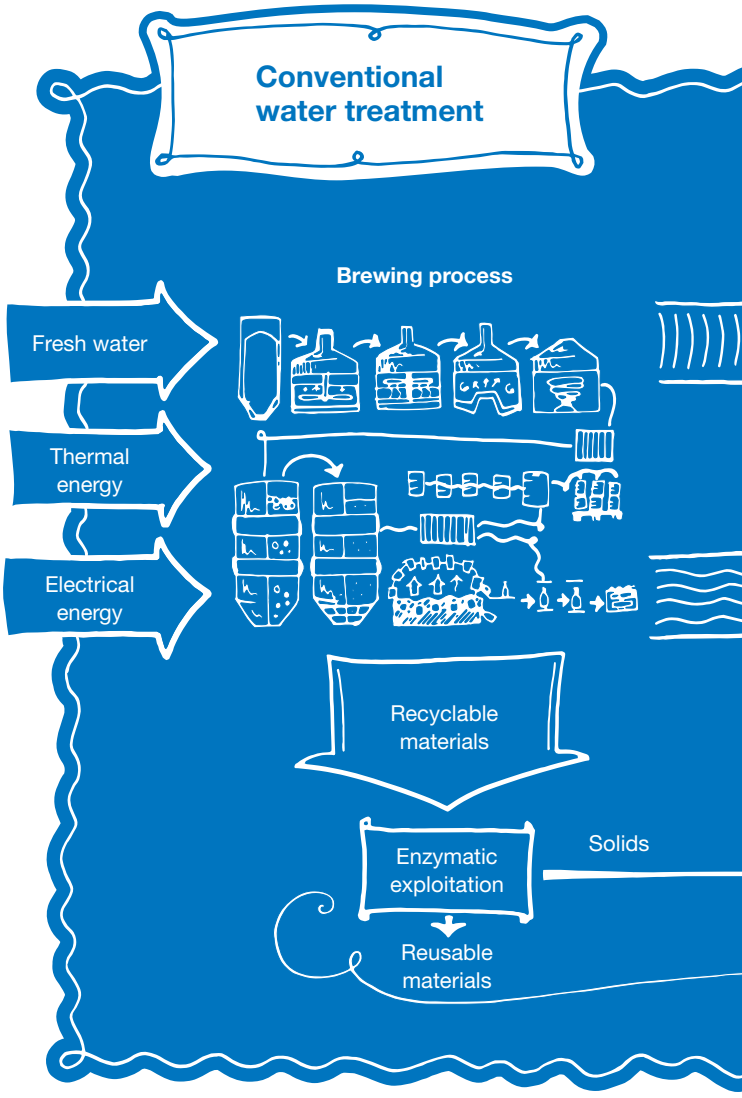
At the interface between water, energy and the environment

AGW takes the interface between water, energy and the environment in the food and beverage industry as its starting point. The scope of its research comprises the development of new techniques for treating drinking water and wastewater, the system and process-driven management of energy and material flows, as well as issues of microbiology and hygiene. It employs methods for simulating chemical-physical processes, analyzing new materials or abstracting and modeling system and process structures. The chemical and biological quality of the water is of fundamental importance in brewing beer. There is not a single stage in the brewing process not affected by the composition of the water. As breweries and beverage companies draw their untreated water either from public water grids or their own wells, its treatment must meet both statutory and brewing criteria. For example, the parameters of water hardness and alkalinity differ considerably from each other, in some cases due to geographical and geological factors. ▷



Karl Glas with the innovative wastewater cleaning pilot plant developed in collaboration with TU Freiberg and commissioned in October 2019.

Picture credits: Stefan Hopf; Graphics: ediundsepp



The brewing industry is aiming to become more efficient

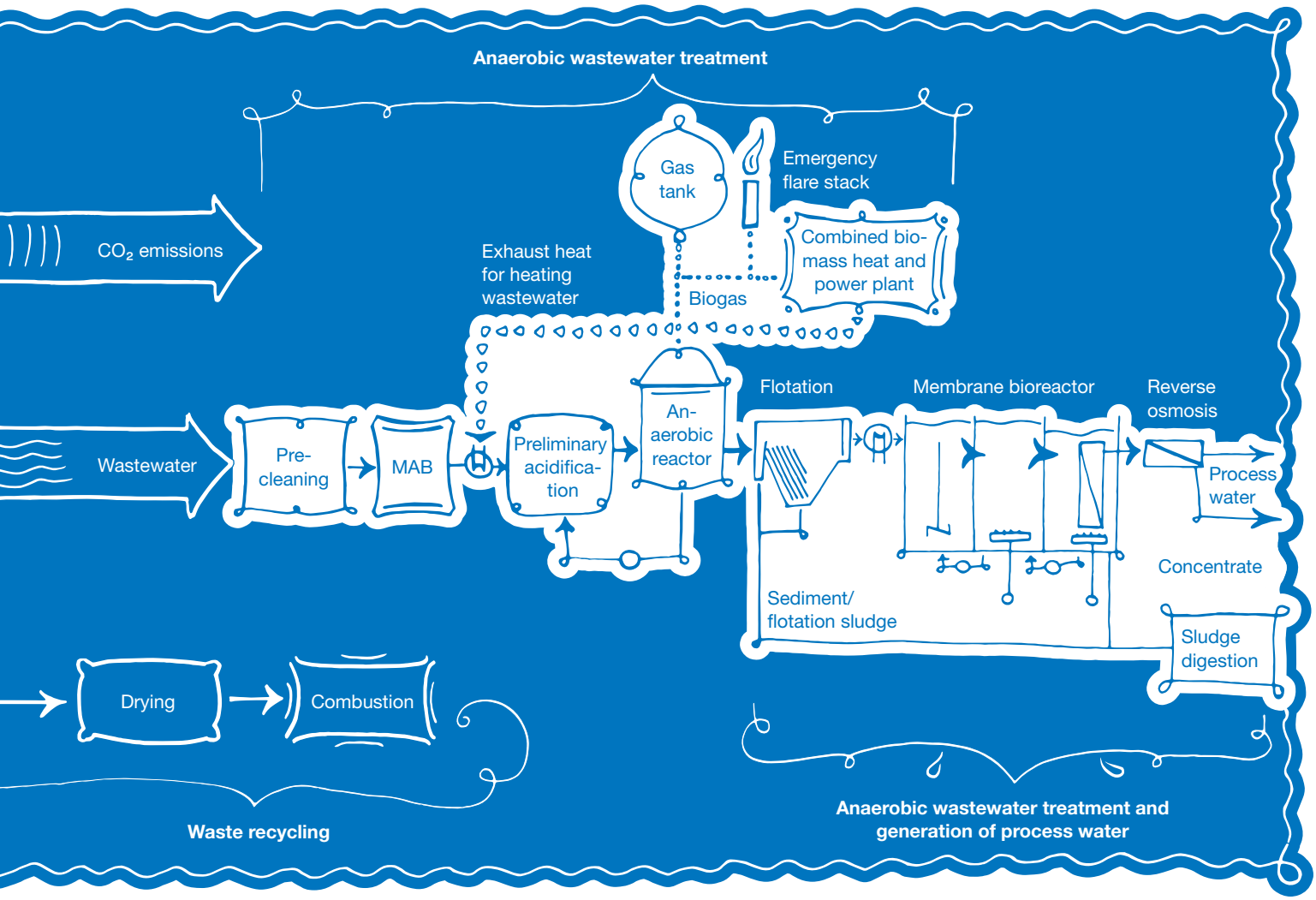
Glas is very well networked within the brewing industry, not least due to his longstanding consultancy work. For example, the two-day "Weihenstephan Seminar for Water Technology" organized by his working group offers a forum every year for promoting dialog between scientists and companies on developments in water technology.

The brewing industry in Germany is a cost-driven business with tight profit margins. Small to medium-sized companies comprise 90 percent of the industry, and they are dependent on fossil fuels and the external procurement of electricity. A volatile energy market, rising energy and raw material prices as well as growing interest on the part of consumers in ecologically sustainable products – these are the challenges facing the industry today. Consequently, the pressure to use energy and water more efficiently is rising, and with it the industry's interest in innovative solutions. Even in the most modern plants, for example, every liter of beer produced generates two liters of wastewater. Glas forecasts that as soon as water becomes noticeably more expensive, German beer brewers will also attempt to treat their entire wastewater in such a way that it can be returned to the production cycle.

Focus on small and medium-sized companies

The AGW is currently developing a modeling and simulation tool with a TUM partner that facilitates a standardized, overarching analysis and forecast of the energy and media consumptions of process chains. Beverage producers and systems manufacturers are thus to be given, for the first time, an integrated tool for tapping previously concealed potential for savings. The quest for self-sufficiency was the starting point for Glas and his working group for this and other running projects. In a feasibility study ("BrauTark"), they previously studied the energy and material flows of a brewery. The researchers identified the potential of the flows, examined the options behind the use of energy and then revealed ways of replacing conventional sources of energy with renewables.

"Brewing is energy-intensive," Glas reminds us. "When you brew beer, you start by boiling the beer wort. That costs no small amount of energy. In the case of smaller breweries, they are naturally not as efficient as large ones in which



production runs continuously. A typical small brewery only has one or two brewing days a week, which means it always has to re-heat the mash. In most instances, these facilities cannot afford to build a wastewater treatment plant." Such companies have mixing and equalization tanks in which the impurity and freight peaks and pH levels of the water are equalized before the wastewater is discharged to the municipality. Frequently, a heavy polluter surcharge has to be paid. In this way, the wastewater also becomes a cost factor. "Self-sufficient plants would alleviate the problem. For example, a small or medium-sized company could produce one CO_2-free batch from Monday to Wednesday and take its time over the next few days to break down its wastewater by means of a fuel cell and even generate electricity in the process," Glas explains. ▷

Every liter of beer generates two liters of wastewater. To date, large breweries have cleaned wastewater in anaerobic reactors (i.e. systems operating without oxygen) with biogas extraction. The current "Brew-Cell" project replaces the section in white, illustrated above, with a fuel cell.

Graphics: ediundsepp (source: TUM)

Brew-Cell: New prospects for integrating energy

Wastewater treatment with the simultaneous generation of electrical energy through the use of microbial fuel cells (MFC) is now set to open up new prospects for the industry. To date, large companies have usually cleaned their wastewater in anaerobic reactors (i.e. systems that operate without oxygen) with biogas extraction. The current "Brew-Cell" project shows how the whole operation can be accomplished on a smaller scale with fuel cells. It is sponsored by the Federal Ministry for Economic Affairs and Energy in its Central SME Innovation Program.

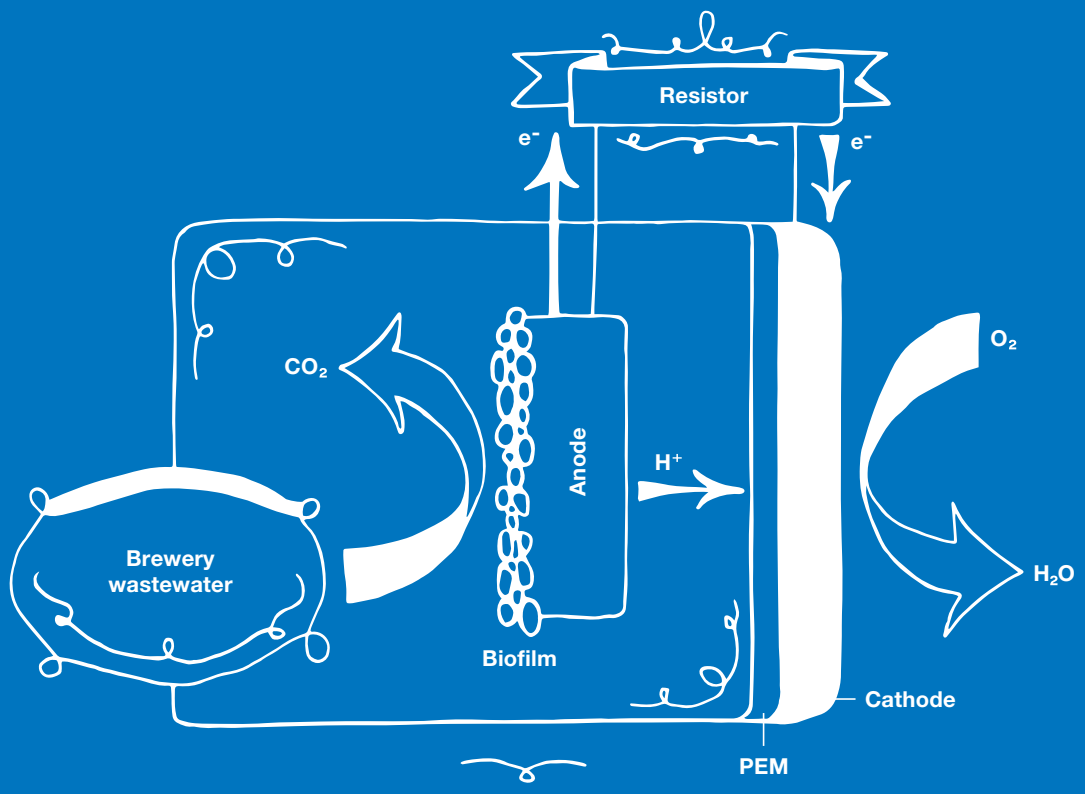
First, researchers selected suitable wastewater flows for the microorganisms, and then conducted basic experiments on a laboratory scale with various designs of MFC. Are "the little helpers", as Glas calls them, unable to tolerate certain disinfectants? Is the wastewater "fatty" enough for them? Good results are only obtained if the design is right. At the same time, the AGW has developed software on the basis of a mathematical model which helps with decisions on design, process set-up and operation at optimum points of the plant. From this, they derived a concept for incorporating the MFCs into the brewery's power management. ▷

"Water is exciting because it's scientific, it's technical, it's political, it's cultural."

Karl Glas

Picture credit: Stefan Hopf; Graphics: edlundsepp

Already successfully trialed in the laboratory on a one-liter scale, tests are now starting in the 100-liter pilot plant. The details for managing the process of wastewater treatment are now being tested out.



BREW-CELL
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The Brew-Cell concept

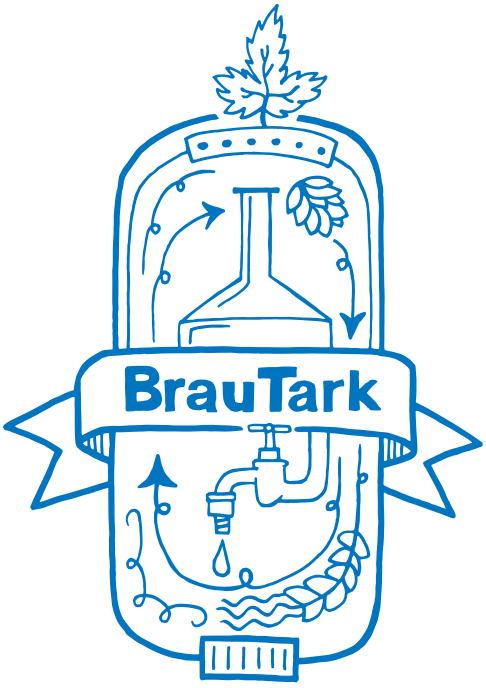
The use of fuel cells to clean wastewater represents a completely new approach. It enables the cleaning of wastewater while generating electricity at the same time. Exoelectrogenic bacteria have the ability to exploit organic substances in the wastewater and to transfer the electrons gained as a result to an electrode. The biofilm on the anode oxidizes a substrate which releases electrons and protons. Electrons are transferred to the anode and flow on to the cathode via an external resistor. In the presence of the protons previously gained, (H^+) oxygen is reduced to water.

Dr. Karl Glas

Karl Glas studied brewing and beverage technology at TUM and obtained his doctorate with distinction in 1988 on the subject of brewery wastewater constituents. Shortly thereafter, he headed the "Special and Environmental Analytics" Department at the Research Center Weihenstephan for Brewing and Food Quality. From 2006 to 2014, Glas was active as the Scientific Director of the Competence Pool Weihenstephan, and between 2010 and 2015 Head of Science/ Research at the Bavarian Research Foundation in Munich. Since 2014, he has been in his current post of Head of the Water Technology Working Group at the Chair for Food Chemistry and Molecular Sensors at TUM, and full-time since 2015. Karl Glas has advised brewing and beverage industry companies in matters revolving around water and the environment both nationwide and internationally for 30 years.

By using different control concepts, it was also possible to determine the particular effects on the process behavior. "We started working with fuel cells a good two years ago. We experimented with prototypes on a one-liter scale in the laboratory. A pilot scheme magnified by a factor of 100 then went into operation in a large brewery in Germany in the fall of 2019." By studying the parameters, the aim is to gain insights into the further upscaling of such systems and their implementation in other areas of industry. There are still a lot of details to be clarified on this road to self-sufficient breweries. The pilot plant run by the researchers from Freising will help to generate valuable experience.

Karsten Werth



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