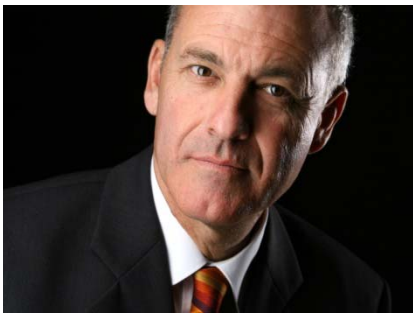
UNIVERSITÄT HOHENHEIM

LANDESANSTALT
für Agrartechnik
& Bioenergie

ANNUAL REPORT 2015

The state institute of agricultural engineering & bioenergy – fit for the future



The year 2015 was also a year filled with the bustling activity of projects that covered an array of topics. All of which the state institute is gladly able to document within this edition of our annual report.

The starting point is an esteemed biogas research that has maintained success for many years, ranking the state institute as one of the leading institutions in Germany that has numerous scientific cooperations at home and abroad combined with close industry links. This translates into practice-oriented research. Recognised scientific bibliometric indicators are used to evaluate our research and reflect the state institute`s highly established position.

Outstanding employees and proper laboratory equipment are the basis for successful research and acquisition of external funding. The renovation and expansion of the laboratories in the research buildings is currently well underway. Unique in Germany and the largest research instrument of the state institute is our research biogas plant, which is situated at “Lindenhöfe” by the experimental stations for agricultural sciences. At present, technical advancements in biogas are performed here in order to ensure a research biogas facility that is fit for the future. Dr. Lemmer is currently responsible for developing an optimum configuration for the research system as well as scientific management of the research biogas plant. The year 2015 saw the planning and partial implementation of the following measures:

- Renewal of the medium voltage supply with a transformer,
- Exchange of cogeneration (power increase from the current 186 kW to a future 350 kW)
- To have a completely self-powered experimental station
- Building application, design and manufacturing schedules for a gas-tight digestate storage (4,800 m³) with an integrated slurry and gas system
- Construction of three sugar-beet mobile silos.

“The University of Hohenheim has made **bioeconomy** the focus of its research and teaching. Unique in Germany, it has the comprehensive expertise necessary to cover the entire value chain of bioeconomy. It covers everything from plant and animal production to new technical processes to the necessary change processes in the economy and society” (Bioeconomy stragety of the University of Hohenheim). The state institute is developing and testing important new technical processes of bioeconomy, which are necessary to profoundly transform the energy supply structure and the economy. The spectrum in fundamental research and development of new processes by the state institute is thereby adequate to monitor pilot plant and evaluate technical equipment at a praxis level. The process technology involved in the fermentative conversion of biomass is a core competence of the state institute.

Through the accomplishments of Dr. Oechsner and Dr. Lemmer, the state institute of agricultural engineering and bioenergy has acquired new research projects and has aligned itself with the with Hohenheim bioeconomy strategy, thus becoming an important component of the work of the university.

Bioenergy production and network system services

The development of renewable energies (wind, photovoltaics) means an increase in positive and negative balancing energy requirements for the power grid in Germany and the EU. In the long run, a greater integration of energy networks (electricity, gas, heat) will be necessary. A decentralized and stabilized energy network system can be achieved on the basis on existing biogas plants. This will ensure that existing power grids need only be expanded to a limited extent and guarantee a nationwide power grid that is stable yet highly efficient.

State institute research is dedicated to a needs-based biogas production that is established on both load profile curves and fermentative power-to gas-technologies:

- Flex Feed: Flexible feeding in biogas processes with model-based process recognition at praxis level. Funded by BMWi
- H2 Transfer: Developing a method to biologically convert hydrogen into biomethane in biogas plants. Project within the power-to-gas field, funded by MWK Baden-Württemberg
- Apply biological methanation for power-to-gas concepts: fermentative high pressure methanation of hydrogen. Funded by MWK Baden-Württemberg
- Bio-Hydro-Methane: Process development to use biological methanation in two-stage biogas production; Subproject 1: Investigation of fixed bed fermenters and completely intermixed reactor. Funded by BMEL

Platform chemicals

Rising commodity prices, scarcity of natural resources, global warming and the desire for sustainable development are the known factors that have led to an increased interest in alternative raw materials, predominantly from biomass. The move from fossil fuels to renewable energies means to switch from oil and gas to renewable raw materials, such as lignocellulose. Inevitably, biomass represents the only alternative to regenerative carbon source used to generate chemical products. For this reason, an aim of bioeconomy is to supply basic chemicals that can be recovered from biomass. Bio-based platform chemicals can develop into an important market for agriculture. One example shows that market for lactic acid is expected to rise from the current 250 000 t/year to 15 million t/year by the year 2020. Dr. Oechsner has succeeded in obtaining two fundamental research projects on this topic:

- GOBI: Integrated optimization of the biogas process chain to improve operational, material, energy and ecological efficiency with particular emphasis on producing a natural fertilizer tailored to the customer. Financed by BMBF
- OptiGär: Development of an efficient two-phase biogas plant via a coupled energetic and material use of feed stocks after the removal of hydrolysis products; Subproject 2: Investigation of decoupled hydrolysis for targeted biogas generation. Funded by BMEL

Energy applications of residual materials and nutrient management

Not only in Germany but especially worldwide, organic residual materials represent a meaningful source of raw materials for anaerobic conversion processes. This can thereby reduce the amount of waste, GHG emissions and reduce the spread of diseases. Residual materials often require treatment before they are ready for use. Nutrient management and nutrient recovery are therefor of great importance. In addition to projects involved in the inhibitory effects of antibiotics in the biogas process and recovery of coffee production waste with partners Brazil and Ethiopia, the state institute is currently working on the following project with nutrient management:

- Optimized substrate management and the influence of digestate composition on soil nitrogen and soil humus content. Funded by BMEL

With these intentions, the state institute not only makes a significant contribution to the sustainable development of the German bioeconomy but also provides reinforcement to the important objective of the University of Hohenheim.

Prof. Dr. T. Jungbluth
Senior director of the state institute of agricultural engineering and bioenergy

Developing a procedure for the fermentative conversion of hydrogen by fluctuating sources of biomethane in biogas plants (H2-Transfer)

As a research area, “Power-to-Gas” (PtG) is gaining more and more relevance and could also be a very important component of the future “energy transition”. Excess electrical energy from fluctuating sources is converted into hydrogen and following methanation is injected into the natural gas grid to be stored as chemical bound energy.

Production of biomethane is acually tested via a catalytical-thermochemical procedure, which is only feasible in big plants. The aim of this project is to achieve a biological methanation. By adding four parts hydrogen, hydrogenotrophic methanogens reduce one part of carbon dioxide and produce one part of methane. Consequently this increases the methane content of the biogas. If necessary, gas purification can follow the methanation process to comply with regulations for injecting biomethane into the natural gas grid.

The plan is to use the one-phase biogas plant system, which is also the system used by nearly all 8.000 german biogas plants. With the results obtained from the coming experiments, we will also examine how to implement methanation of hydrogen into existing biogas plants.

Preliminary tests using a fermenter with 400 liter working volume had shown a rise in the methane content from 52 % to 75 % (with half-stoichiometrically injected hydrogen). The carbon dioxide content had therefore decreased. Later in the project, four fermenter systems equipped with measurement equipment and online data are planned for construction. Using these systems, hydrogen injection systems will be tested and adapted, as well as testing optimal parameters for conversion i.e. fermentation temperature, volumetric loading rate and hydraulic retention time. In the long run, a successful injection system will be temporarily implemented into the search biogas “Unterer Lindenhof”.

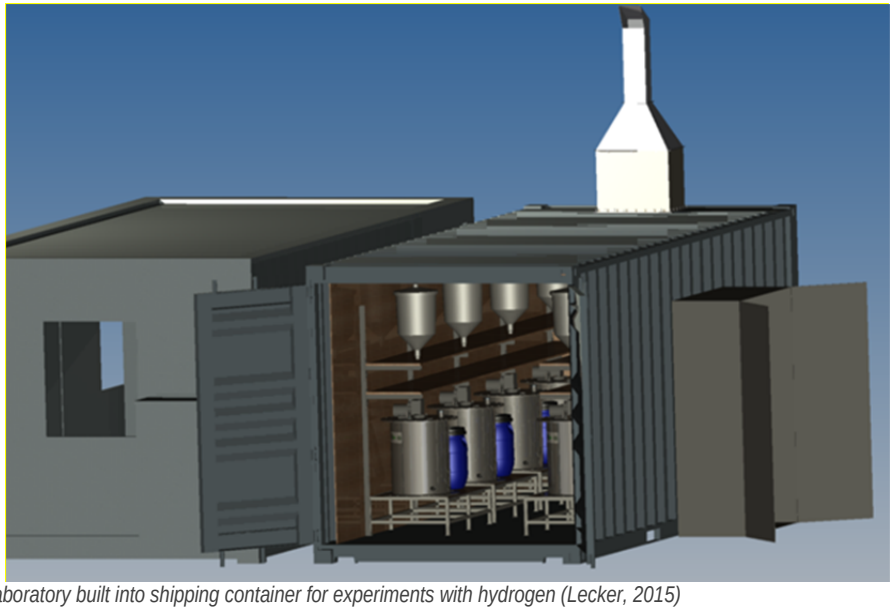
M. Sc. Bernhard Lecker

M. Sc. Colin Kohler

Dipl.-Ing. agr. Christoph Serve-Rieckmann

B. Sc. Daniel Riehle

Dr. sc. agr. Hans Oechsner



Laboratory built into shipping container for experiments with hydrogen (Lecker, 2015)

Funding:
Ministry for Science Research and Art Baden-Württemberg „Bioökonomie-Projekte“

Partners:
DVGW Research Unit at Engler-Bunte-Institut (DVGW-EBI), KIT

Project duration:
June 2014 – Sep 2017

Process development for the use of biological methanation in two-stage production of biogas; Subproject 1: Investigation of a fixed-bed fermenter and continuous stirred tank reactor (BioHydroMethane)

Dr. sc. agr. Nicola Leonard Haag

B. Sc. Daniel Riehle

Dr. sc. agr. Hans Oechsner

The planned expansion of renewable energies in Germany requires considerable storage capacity for electrical energy, which in this size, can only be provided by chemical energy carriers. The biological methanation of hydrogen in the biogas digester is a promising alternative to the catalytic methanation.

This project will investigate the two-stage digestion with separate hydrolysis and the targeted introduction of hydrogen into the methane reactor. A particular advantage of this approach is that the carbon dioxide produced during the bigas process can be used by hydrogenotrophic methane bacteria, which almost completely convert it to methane. Subsequently, the biogas can be injected into the natural gas grid as biomethane and compared to conventional biogas, has significantly lower treatment costs or can be used as fuel.

As part of this joint project, which consists of three sub-projects, technological tests with different reactor designs, such as fixed-bed, continuous stirred tank reactor and membrane reactors are carried out on a laboratory scale. Developing a technique to inject fine bubble hydrogen into the fermenter liquid will be a fundamental task in achieving an optimum supply for the methane bacteria. Additionally, we will examine the influence of bubble size, injection technique as well as the design of the bubble ascension on the transfer efficiency to the digester liquid and the methane bacteria. A special emphasis will be given on the change of the biological community by adding hydrogen to the methane reactors. By measuring the composition and concentration of volatile fatty acids, the buffering capacity, the pH-value, the concentration of dissolved gases in the fermentor substrate and the quality of the resulting product gases, the reactor types will be evaluated, optimized and refined.

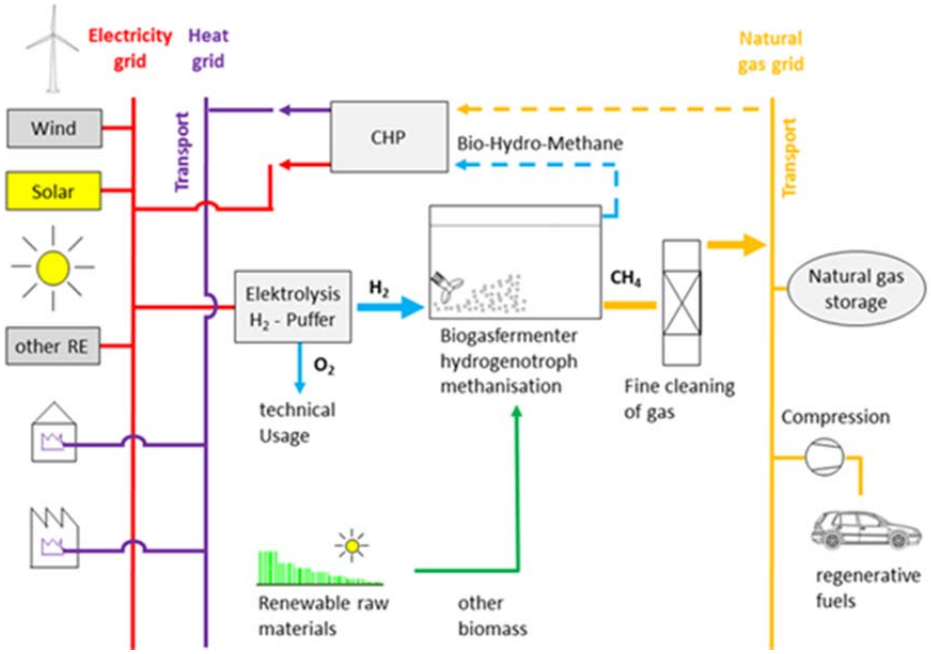
Funding:
Federal Ministry of Food and Agriculture

Fachagentur Nachwachsende Rohstoffe e.V. (FNR)

Partners:
DVGW Research Unit at Engler-Bunte-Institut (DVGW-EBI) – Water-chemistry and water-technology

Leibniz Institute for Agricultural Engineering Potsdam-Bornim (ATB)

Project duration:
May 2015 – May 2018



Concept: Bio-Hydro-Methane production

Use of biological methanation for Power-to-Gas Concepts: Fermentative high-pressure methanation of hydrogen

M. Sc. Timo Ullrich

Jochen Harder

B.Sc. Lukas Illi

Dr. sc. agr. Andreas Lemmer

As part of the energy turnaround, the existing, centrally-oriented energy system that is largely based on conventional energy generation must shift towards a decentralized and regenerative system with a high share of renewable energies. However, to integrate fluctuating renewable energies into the electricity market requires load-side flexibility for further expansion.

For this purpose, the biological high-pressure methanation of carbon dioxide and hydrogen to methane represents a very promising option and should be examined as part of this project. In this procedure, carbon dioxide is converted in a pressure reactor to methane as part of the biogas with hydrogen, which is produced by electrolysis using wind and solar energy. This "biomethane" can be used as fuel in automotive industry or fed into natural gas networks. Fermentative high-pressure conversion of hydrogen to methane is therefore a solution to a sustainable energy supply in rural areas. By linking various energy production and transportation systems this process also promotes efficient energy-storage and transportation.

Examining trickle-bed reactors for methanation is a new concept, which promises significant advantages over alternative methods. As an example, the fixed bed allows an intensive contact between microorganisms and gases, and increasing the reaction pressure up to 10 bar improves the problematic gas solubility. With this new concept, there are expected to be higher gas and methane yields which means a more efficient and economic methanation for the practice.

For this reason, there are plans to construct a laboratory-scale facility used to operate and implement the measuring and control technology required. Subsequently, a test series will be used to optimize operating parameters such as loading rates, retention time, pressure and temperature. After successful development of the optimum operating parameters, the ultimate aim is to establish a concept for a large-scale plant.

Facility at laboratory scale for fermentative high-pressure methanation of hydrogen and carbon-dioxide

Funding:
Ministry of science, research and art Baden-Württemberg

Partners:
DVGW Research Unit at Engler-Bunte-Institut (DVGW-EBI)

Engler-Bunte-Institute of KIT (KIT-EBI)

Project duration:
June 2014 – June 2017

Bio-electrochemical production of high calorific biogas from waste materials

M. Sc. Padma Priya Ravi

Jochen Harder

B.Sc. Lukas Illi

Dr. sc. agr. Andreas Lemmer

The preliminary idea of this project is to utilize the huge quantities of organic wastes available throughout the world for energy production.

The aim of this project is to convert the biogenic residues to high calorific biogas by small, compact and efficient systems called microbial fuel cells, which are flexible for various substrates like supermarket waste and food waste. The technical approach of the project is to combine the fermentation process with bio-electrochemical process: the biomass is first degraded by fermentation to volatile fatty acids (VFA) which are subsequently introduced into the bio-electrochemical reactor.

The overall objectives of the joint research project is to test and develop suitable anode and cathode materials including the development of new process-adapted electrode structures. Furthermore, investigating the biological diversity of microorganisms on electrodes and their targeted influence as well as the technical integrating of the bio electrochemical process to fermentation process in lab scale are in the focus of the project.

The concept of the project is to use specific waste residues for fermentative acidification process and then introducing the organic acids, H_2 and CO_2 produced in a microbial electrolytic cell. In the anode chamber, exoelectrogenic bacteria degrade the organic acids to electrons, protons and CO_2. These electrons are transferred to cathode chamber through an external circuit and the protons through proton exchange membrane (PEM). In the cathode chamber, methanogenic bacteria convert electrons, protons and CO_2 to high calorific methane.

The work objectives of state institute is to investigate VFA production by fermentation and the design and construction of a lab-scale process combining fermentative acidification reactor with the bio-electrochemical system under technical aspects.

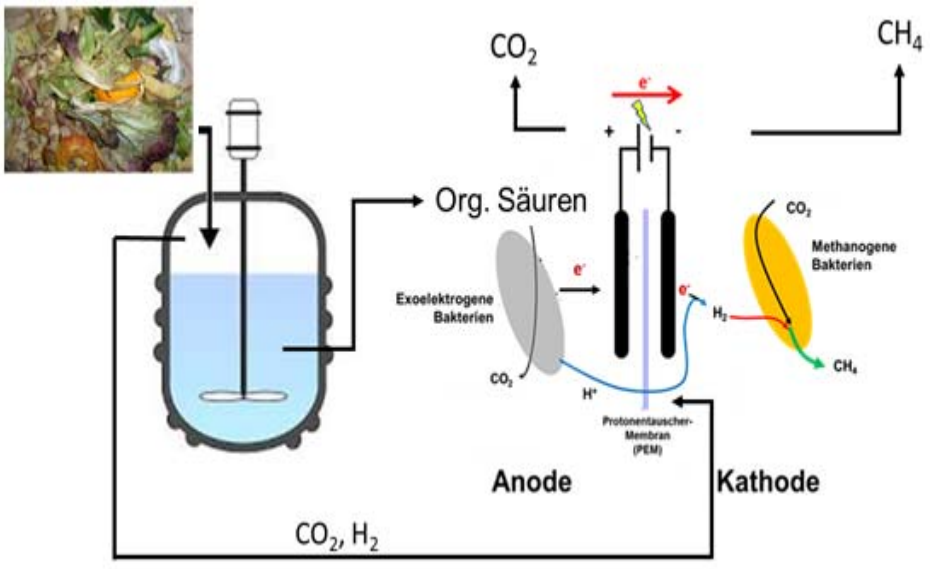
Funding:
Projektträger Karlsruhe – Baden Württemberg Programme

Partners:
Karlsruhe Institute of Technology (KIT)
Institute of Applied Biosciences (IAB)

University of Freiburg
Department of Microsystems Engineering (IMTEK)

University of Stuttgart
Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA)

Project duration:
Sep. 2015 – Aug. 2018



Project scheme

Development of sensor technology and basics for a flexible load dependent intermediate production in two stage anaerobic digestion systems by a fully substrate utilization (Elast2P)

M.Sc. Jonas Lindner

Jochen Harder

B.Sc. Lukas Illi

Dr. sc. agr. Simon Zielonka

Dr. sc. agr. Andreas Lemmer

The expansion and use of weather dependent renewable energies like photovoltaic and wind power lead to fluctuations in the electricity grid. As a result, it is becoming ever more important to develop production processes for balancing renewable energy fluctuations. The answer may be in biogas, an easily storable and transportable energy source. Two-stage biogas plants are particularly suitable for flexible electricity generation. However at its current stage of development, the full potential of this technology it not yet able to be realized.

In the research association “ELAST2P”, two objectives will be investigated at the University of Hohenheim:

- Sensor-guided, load-dependent methane production in a two-stage system.
- Increasing of the overall efficiency by a mechanical-biological treatment of the non-degradable fibres and a subsequent return to the process.

We will perform the experiments at two-stage biogas plants consisting of a continuous stirred tank reactor as the acidification reactor and an anaerobic filter as the methanogenesis phase. The project is subdivided into four working packages:

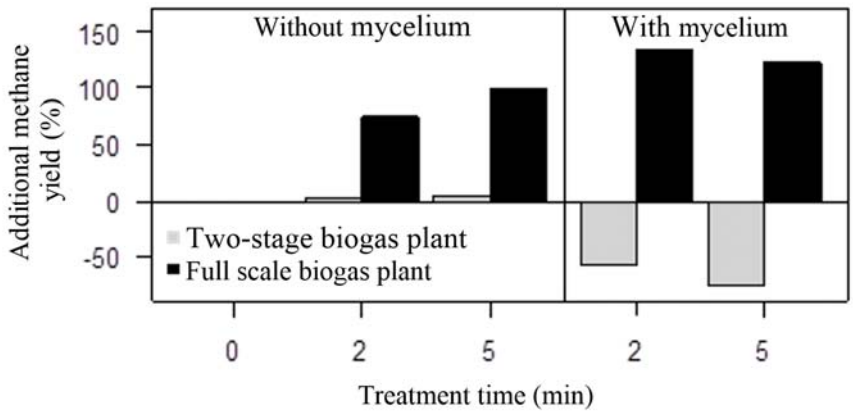
WP1: During the primary formation, the organic acids, alcohols and sugars that are formed have must be separated from the undigested fibres. At this part of the project, we will investigate how different filter sizes and substrates affect the intermediate separation in the acidification reactor.

WP2: To improve the overall substrate degradation rate, we will determine how the methane yield will be affected by a combined mechanical treatment with a ball mill, together with an additional biological treatment by aerobic fungi of only the non degraded fibres, and a subsequent refeeding to the process.

WP3: An online measurement of the intermediate concentration and composition is necessary for a load dependent operation of the anaerobic filter

Therefore an acoustic waveguide sensor for online measurement of the intermediate concentrations and compositions has to be calibrated.

WP4: For a load dependent methane production, the feeding of the system needs to be coupled with mathematical models. The aim of this WP is to test such a model in a two-stage system developed by the Goethe University Frankfurt (G-CSC).



Influence of a combined mechanical / enzymatic treatment (mechanical: treatment time 0, 2, 5 min; enzymatic treatment: with aerobe Shiitake mycelium, incubation period 29 days) on the digestates (substrate hay/straw, maize silage) of a two-stage system and of a full scale biogas plant on the additional methane yield

Funding:
Federal Ministry of Education and Research (BMBF)

Partners:
The Institute of Agricultural and Urban Ecological Project at Humboldt-University in Berlin (IASP)

Johann Wolfgang Goethe-University Frankfurt am Main: The Goethe Center for Scientific Computing (G-CSC)

Bavarian State Institute of Agriculture, Freising (LfL)

Project duration:
01.12.2012 - 31.03.2016

MethanoQuant - Quantifying ways of methane generation in two-phased anaerobic digestion

M.Sc. Johannes Krümpel

B.Sc. Lukas Illi

Jochen Harder

Dr. sc. agr. Andreas Lemmer

Dr. sc. agr. Simon Zielonka

In science, the two-phase process to produce biogas is gaining increasing attention due to its high process stability, substrate flexibility and high methane contents of the produced biogas. The goal of our project is to describe the process of two-phased biogas production through mathematical computing in order to lay the foundations for a rapid and purposeful development of the process. Within the framework of the project, we will therefore conduct fundamental research at the State Institute of agricultural engineering and bioenergy. In this respect, we shall identify which individual components of process liquids from anaerobic filters are responsible for the methane generation. To accompany this, we intend to describe the individual gas production kinetics of these components. Our mathematical models will be adjusted and verified in accordance to the data in order to build the basis towards further optimizing the process.

As part of the experiment, three anaerobic filters of identical construction will operate continuously. The data is acquired online in high resolution to construct an exact picture of the process. The process liquids are analyzed by GC and HPLC. The total organic carbon (TOC) is determined by the differential method from total carbon (TC) and inorganic carbon (IC) analysis. The experimental reactors are designed to be easily exchangeable so to enable research on different reactor types. In the year 2014, the plants put into operation and we derived the first carbon balance.

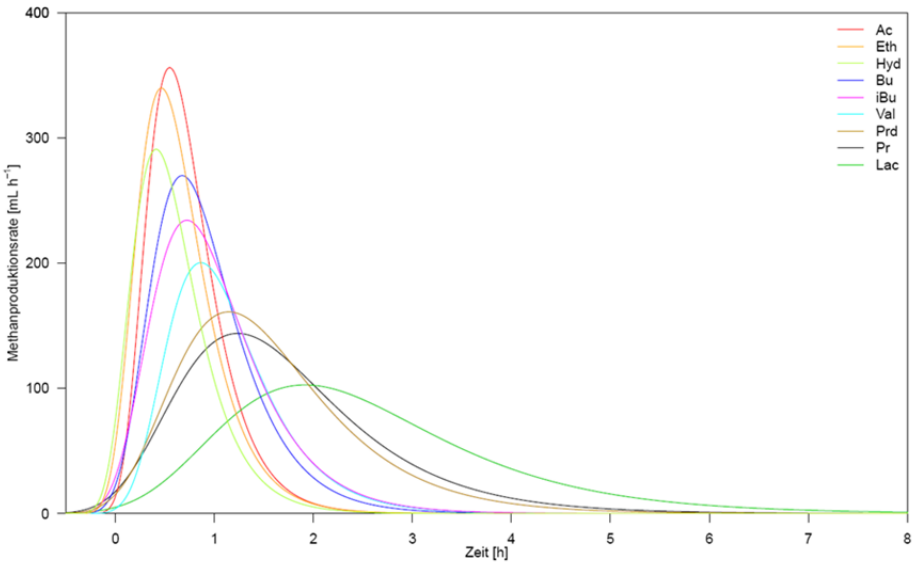
Funding:
Federal Ministry of Education and Research (BMBF)

Partners:
Brandenburg University of Technology Cottbus – Senftenberg (BTU)

Goethe Center for Scientific Computing (G-CSC), Goethe University Frankfurt

Steinbeis Research Center Technical Simulation

Project duration:
01.11.2012 - 31.08.2016



Methane production rate in the Anaerobic Filter of common Intermediates (Injections of 1g COD). Ac: Acetic Acid, Eth:Ethanol, Hyd:Hydrolysate, Bu: Butyric Acid, iBu: iso-Butyric Acid, Val: Valeric Acid, Prd: 1,2Propanediol, Pr: Propionic Acid, Lac: Lactic Acid"

Autogenerative two-phase high pressure fermentation - AG-HiPreFer

The aim of our project is to integrate biogas production, purification and pressure boosting into one process. By avoiding the compression stage, we will thereby save up to 30% of energy consumption for the gas conditioning.

We will develop a new, two-phase pressurized anaerobic digestion process, that contains an autogenerative increase of the pressure in the digester up to 100 bar (AG-HiPreFer)- The process in turn produces biomethane of natural gas quality inside the methane reactor, which can then be fed directly into the grid. In contrast to other commonly used technologies, no additional chemicals or compression are needed. This novel bio-physical process additionally takes advantage of the fact that CO_2 is more soluble than methane, resulting in a higher CO_2 content in the liquid phase at increased pressures. We are able to reach methane contents of over 92% in the gas phase.

We will perform additional research on how to integrate an anaerobic Microbial Fuel Cell (AMFC) into the process in order to improve overall process efficiency.

The appropriate measurement and control concepts for process monitoring at operating pressures up to 100 bar have to be established within the project framework. We aim to furthermore develop a membrane concept for separating acids formed during the fermentation process. Within the project, we will perform experiments on the solubility of gases in the methane reactor as well as analyses that clarify how pressure influences the microbiological process in the methane reactor.

We furthermore will research the fundamentals of the aMFC, which uses the difference of the redox potential and hydrogen ions between the acidification reactor and the pressure methane reactor for a direct generation of electricity via carbon, stainless steel or iron cyanide electrodes. A system-analytical consideration and an economic evaluation of the process will round off the project.

M.Sc. Wolfgang Merkle

M.Sc. Jonas Lindner

Jochen Harder

B.Sc. Lukas Illi

Dr. sc. agr. Simon Zielonka

Dr. sc. agr. Andreas Lemmer

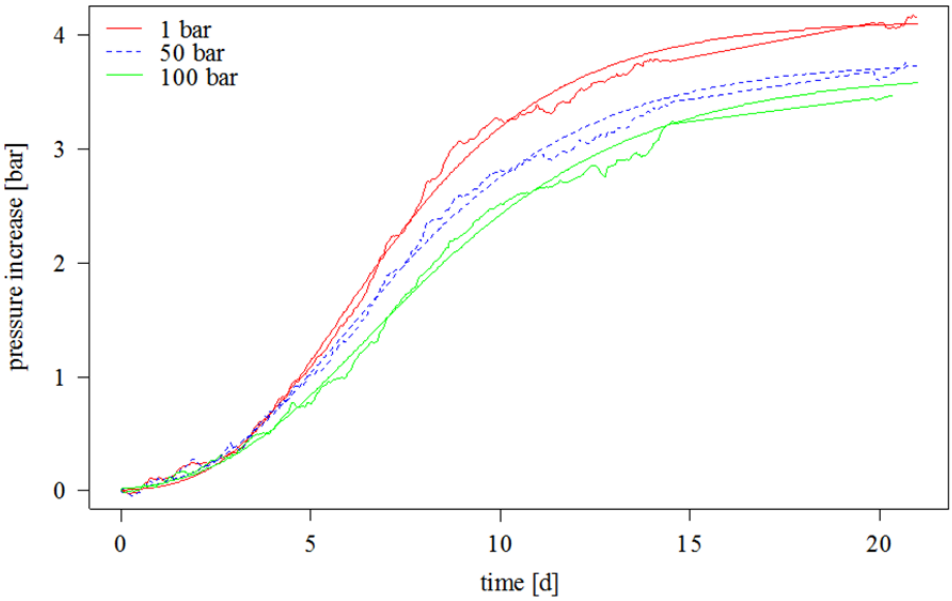
Funding:
Federal Ministry of Education and Research (BMBF)

Partners:
DVGW-Research Centre at the Engler-Bunte-Institute of Karlsruhe Institute of Technology (KIT)

Johannes Gutenberg University Mainz, Institute of Microbiology and Wine Research (IMW)

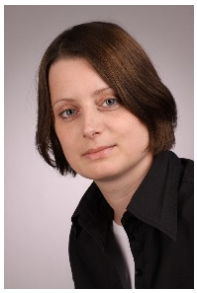
Associated partner:
Centre de Recherche Public Gabriel Lippmann, Département Environnement et Agro-biotechnologies (CRP), Luxemburg

Project duration:
01.07.2013 – 31.12.2016



Pressure formation curves over time working with three different admission pressures (1, 50, 100 bar)

Two-phase anaerobic digestion of sugar beet for biomethane production – Process optimization of preservation and conversion for the improvement of energy yield (ZRCH4)



M. Sc. Elzbieta Kumanowska

Jochen Harder

B.Sc. Lukas Illi

Dr. sc. agr. Simon Zielonka

Dr. sc. agr. Andreas Lemmer

Dr. sc. agr. Hans Oechsner

The aim of this project is to offer the biogas plant operators an ecologically, energy-oriented and economically superior method. Our focus is to produce a high caloric biogas for the use as fuel or as SNG, which in turn provides an alternative to previous applications of electricity production.

To achieve this objective, we pursue a bilateral approach. We use the rarely-applied substrate sugar beet, which improves the ecology of the process and furthermore allows us to optimally use new process technology.

The first step is to develop a novel, optimal method to preserve the sugar beet. Accordingly, the results of storage tests and laboratory experiments are compared with those of conventional storage processes. As such, we are able to duly evaluate how preservation methods influence the energy yield.

The next step is to determine how suitable the ensiled sugar beets are for digestion within two-phase anaerobic digestion laboratory systems and to optimize crucial parameters. The new biological conversion processes are able to fractionate the biogas already during the production. This in turn increases significantly the methane content of the biogas. We are able to therefore reduce the cost of preparing biogas to a natural gas quality, and furthermore utilize the gas as a fuel. Producing biomethane could be an alternative for generating electricity using a CHP unit. The problem of using heat when converting biogas in a CHP unit is furthermore eliminated.

Although problematic in conventional biogas plants, sugar beet is an almost ideal substrate for the two-phase anaerobic digestion. With high sugar content and a low level of undigestible materials, such as lignin, sugar beet is very suitable for acidification.

Funding:
Federal Ministry of Food and Agriculture (BMEL)

Fachagentur nachwachsende Rohstoffe (FNR)

Partners:
Novatech Corporation

Research Stations:
“Unterer Lindenhof“ and “Ihinger Hof”

Project duration:
01.09.2014 – 31.08.2017

Storage experiment of sugar beet chips in flexible tanks at “Ihinger Hof” research station

Flexible feeding in biogas processes with model-based process detection in full-scale - FlexFeed

M. Sc. Philipp Kress

Dr. sc. agr. Hans-Joachim Nägele

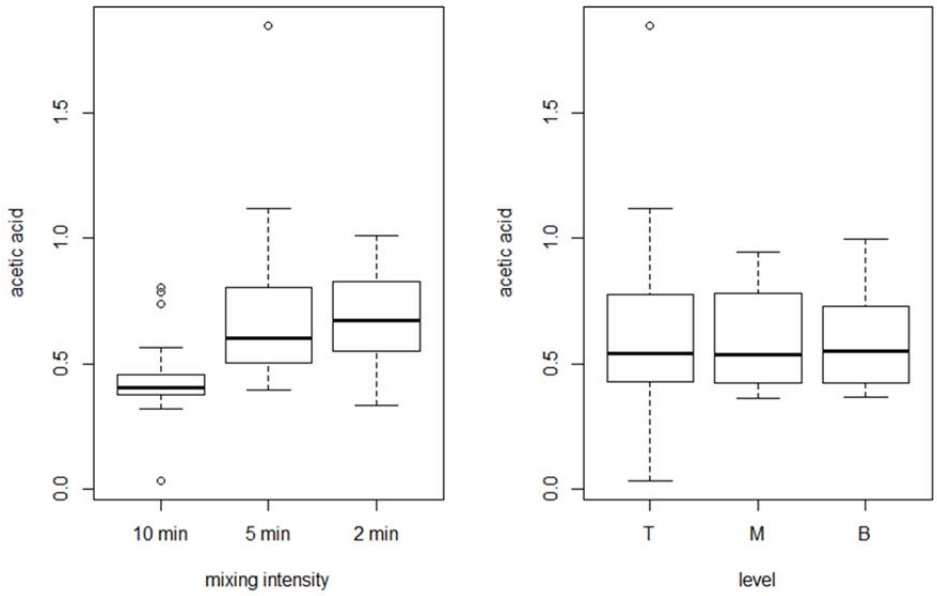
Dr. sc. agr. Hans Oechsner

Due to a decrease in farming area, the availability of raw materials as well as the current political conditions, biogas producers are using measuring techniques to either increase process efficiency or provide an alternative income. Biogas plants has the potential to secure the supply and stability by increasing dynamics in the power grid. As the gas treatment process is not profitable for many existing biogas plants, the idea here is to test and increase the flexibility of power production chiefly expanding gas storage and of co-generation unit.

With the help of storable biomass, it is possible to operate the fermenter in a controllable and flexible manner through optimized feeding management techniques. The impacts of the widely varying feeding management techniques on the biological, rheological process engineering parameters are not known clearly. It is expected that through the flexible process management unknown conditions occur in the fermenter. They can endanger the undisturbed plant operation. It is therefor necessary to develop a strategy for innovative process monitoring and sample collection.

The aim of the project is to evaluate and optimize the strategy for feeding management in biogas plants. This strategy includes the combination of innovative sensor in the liquid phase, model based monitoring and neural work as methodological approaches. This project is further divided into 3 different work packages:

- Package 1: Identification of crucial zones in the biogas digester
- Package 2: Installation and validation of the acoustic waveguide and near-infrared spectroscopy
- Package 3: Verification of developed models for a full scale biogas plant



Distribution of acetic acid concentration in the digester dependent on the mixing intensity and the level (Ruile 2015)

Funding:
Federal Ministry of Economic Affairs and Energy

Fachagentur nachwachsende Rohstoffe (FNR)

Partners:
Technical University - Berlin

SOTA Solutions (Berlin)

Project duration:
01.08.2014 – 31.07.2016

Investigations on alternating load operations at the research biogas plant „Unterer Lindenhof“ under the project Bioenergieflex

Dr. sc. agr. Hans-Joachim Nägele

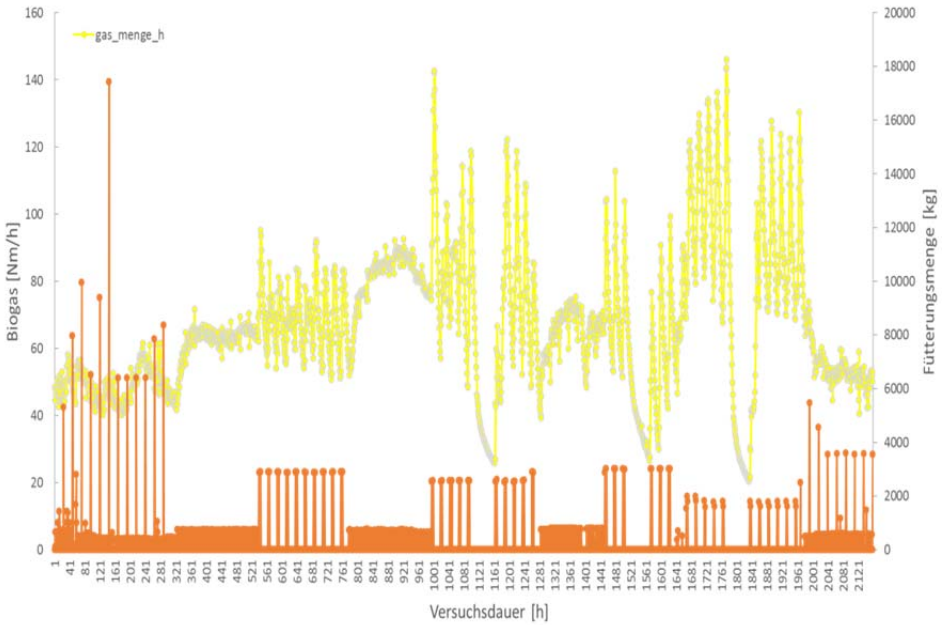
Dr. sc. agr. Hans Oechsner

The task for this project was to investigate flexible biogas production by varying the daily substrate doses within a full-scale biogas plant. Unlike previous investigations, the main focus was rather on single substrates than mixtures of substrates. Three indivudal substrates were tested each in combination with fluid and solid manure. Approximately 4 m³ of liquid manure, 0.8 t of solid manure, and 4.5 t of indivudal substrate were the quantities added daily during the experimental period. The liquid and solid manure was fed together to comply with the German Renewable Energy Law as well as stabilizing process biology. The substrates that were tested within these investigations were:

- A combination of grass silage & maize silage
- Grass silage
- Maize silage
- Grain

Each individual substrate was tested over a duration of 12 days and included a transition period of three to five days and subsequently seven days were deciated to measuring. Between each test phase there were 14 days of continuous feeding and the input substrate was changed to the next on a step-by-step basis.

Following the measurement phase, the project partner was informed on gas quality, the amount of gas produced and the supplied subsrate amounts with DM and oDM analyses for each input substrate. Data was delivered in the format of excel tables with the first graphical evaluations of process control. A brief description of each investgation step was provided. A joint publication of research results with the project partner is currently pending.



Gas flow and gas quality during the investigation period

Funding:
Service contract with: Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA)

Partners:
Institute for Sanitary Engineering, Water Quality and Solid Waste Management (ISWA)

Project duration:
2 month

A study on the measuring the efficiency of a new and innovative biogas-substrate stirrer and its flow behaviour

Dr. sc. agr. Hans-Joachim Nägele

Dr. sc. agr. Hans Oechsner

For this research project, an exceptionally innovative bionic stirrer from the specialist WUSOA with two residence times (about 180 days) will be installed in one of the two biogas digesters at the research biogas plant „Unterer Lindenhof“ of the Lindenhof agricultural research stations at University of Hohenheim. In particular, the following factors will be tested:

- Primary energy consumption (ongoing)
- Quantity and quality of biogas produced (ongoing)
- Nutrient distribution in the fermenters (12 measuring points, 3 heights - every 2 months)
- Biological process activity of the digestate in the fermenter (fornightly)
- Viscosity of fermenter contents using a pipe viscosimeter (every two months)
- Flow pattern (together with Fraunhofer IKTS in Dresden)
- Comparison of the new measurement data to existing facility stirrers)

Current the stirring equipment used at research biogas plant will be first tested during a preliminary examination period. This will be followed by the installation and examination of the new stirrers and a under conditions comparable to those of the previous. Performance and efficiency of the new stirrers to the old stirrers will also be compared.

The project kicked off in March 2015 and data has so far been acquired on the distribution of nutrients, gas quality and quantity, primary energy consumption, digestate viscosity and process biology for the conventional stirring facilities. Installing the new, bionic stirrer followed in August 2015. A collection of same measurement data as well as a comparison of the different stirrers will be performed at a later date. During construction of the stirrer by the company WUSOA, abiding by the specific conditions of the existing digester had caused delays. Installation and investigations that are planned for part two of the project are expected to follow in April/May of 2016 once the adjustments to the stirrer have been completed.

Components of bionic agitator and a conventional stirrer made of sintered polyamide in model-scale for the lab tests to measure flow pattern.

Funding:
The state of Baden Baden-Württemberg as part of the Baden-Württemberg program

Project duration:
Proposed March 2015 – Realization in 2015 – Extended until July 2016

A comparative analysis of chemical desulphurisation in the biogas process – Trial III

Dr. sc. agr. Hans-Joachim Nägele

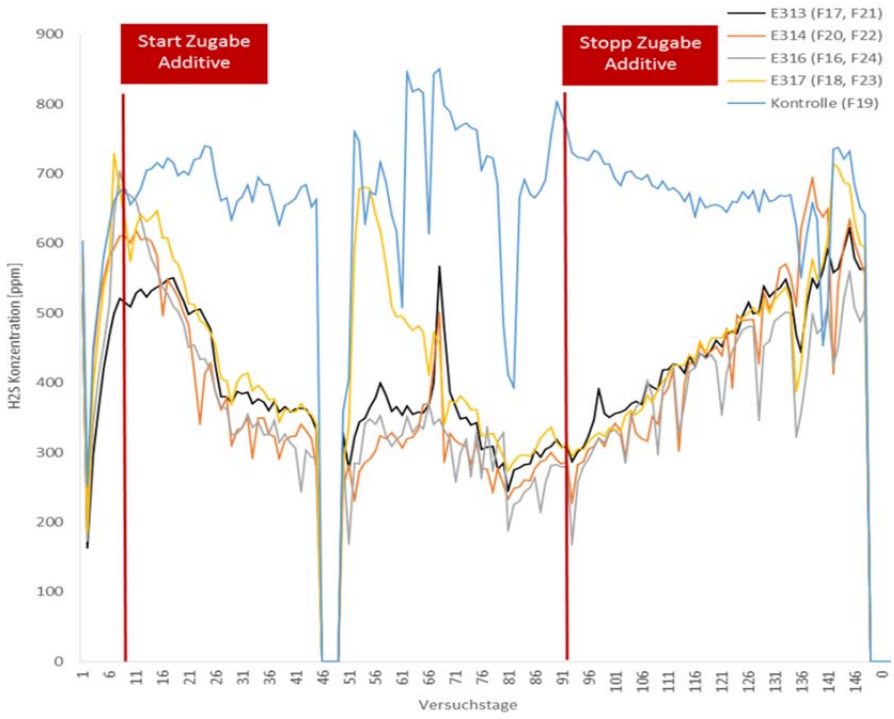
B. Sc. Jörg Steinbrenner

Dr. sc. agr. Hans Oechsner

Building on the trials from the years 2013 and 2014, a further trial has been commissioned by LANXESS Germany GmbH under the laboratory conditions of the 30 litre continuous digestion system. The aim of this study is to compare iron salts of different production sites and origin of LANXESS Germany GmbH with regards to their desulfurization performance in the biogas process. The initial substrate is provided by our research biogas plant „Unterer Lindenhof“. Then input substrates have been pretreated for 15 seconds in a cross flow grinder are made of the following mixture which is added once a day:

- Solid manure (Cow/Chicken) ~20% share
- Grass silage ~30% share
- Maize silage ~20% share
- Raw sludge ~30% share

The target volume during the tests was 3 kg oDM/m³ * d at a process temperature of 40°C and a hydraulic retention time of 38 days. The tested preparations (iron salts) were provided by LANXESS. The laboratory of the state institute for agricultural engineering and bioenergy has continuously determined the DM and the oDM of the initial samples and those in the fermenter substrate. LANXESS had received the results of the H_2S content in the biogas after the start-up phase which would be used to determine the required application rates for optimum desulphurisation. Adding the salts was able to successfully reduce the hydrogen sulfide content. The effects of the iron salts also persist for a certain amount of time after addition has ceased.



Hydrogen sulfide concentration of the different variables during the trial period

Funding:
LANXESS Germany GmbH

Partners:
LANXESS Germany GmbH

Project duration:
Aug. 2015 – April 2016

Emission potential of digestion residues with determination of the residual methane potential

It is very much necessary to utilize the energy contained in input materials in order to operate biogas plants with an economical and environmentally friendly approach. In practice, today's biogas plants vary widely in their structure, input materials and the digestion process. As a result, an efficient use of the substrate may differ from plant to plant.

Previous studies have shown that an optimal operation is not present in all digester systems. This depends on the particular design of the digester, on the inserted substrate and the interconnection of the digesters. Important parameters here are the organic loading rate (OLR) and the hydraulic retention time (HRT). These factors have a high influence on the residual methane potential of biogas plants. By increasing the residual methane potential of the substrate there is a danger of uncontrolled methane emissions during storage in uncovered containers. This in turn has a negative impact on our climate. As a preventative measure, the German renewable energy law (EEG) of 2012 has established that newly constructed biogas plants must have a minimum retention time of 150 days in the gas-tight area. The VDI guideline 3475 also recommends that the residual methane potential of biogas plants using renewable resources needs to be below 1.5% of the daily produced biogas. Small farm site plants that use slurry and manure from livestock production, as well as bio waste fermentation plants, reduce uncontrolled methane emissions of the substrates and do not need to comply with regulation.

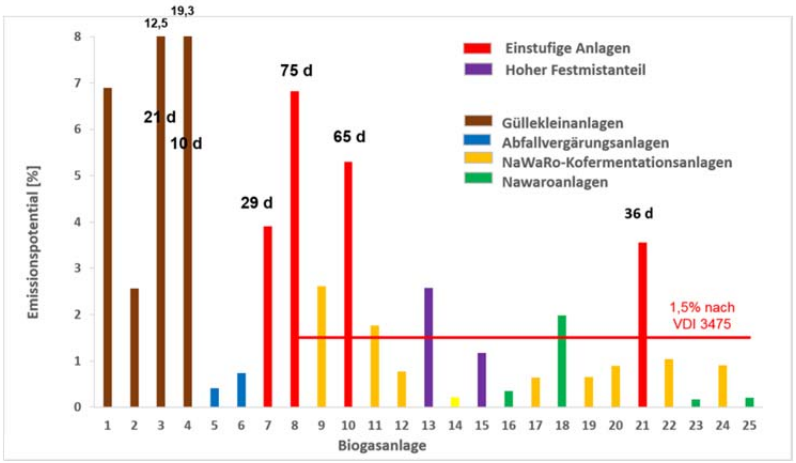
In our project we have analyzed residual methane potential of 25 biogas plants in Baden-Württemberg that vary in terms of fermentation and feeding. The results show that the various systems differ significantly with regard to their degradation efficiency. The starting materials and the retention time are the main parameters affecting the residual methane potential of biogas plants. Covering the storage containers is an important measure in order to minimize the residual methane potential of a biogas plant.

B. Sc. Stephan Ruile

B. Sc. Sabine Schmitz

Dr. sc. agr. Matthias-Mönch-Tegeder

Dr. sc. agr. Hans Oechsner



Emission potentials for the plant categories (input substrates) of the 25 investigated biogas plants as percentage (%) of the daily produced biogas with a batch test temperature of 20 °C

Funding:
Ministry of the Environment, Climate Protection and the Energy Sector, Baden-Württemberg

Project duration:
Nov. 2013 – Dez. 2015

GOBi "General Optimization of Biogas Processes"

Dr. sc. agr. Nicola Leonard Haag

Dr. sc. agr. Hans-Joachim Nägele

CTA Christine Baur

Dr. sc. agr. Hans Oechsner

The increasing scarcity of fossil fuels and anthropogenic climate change calls for the energy system to convert to renewable energy sources. This represents a major challenge for science, politics and society, which requires the great efforts of all stakeholders over the next decades. The aim of our research project is to increase the efficiency and sustainability of the biochemical conversion of biomass, by not only focussing on the energy yield but on the overall benefit of an improved process. Improving the process can be achieved by producing valuable by-products, as well as reducing negative environmental effects, most notably greenhouse gas emissions. For this purpose, the transdisciplinary working group sets several, interlocking sub-goals.

The State Institute of agricultural engineering deals with the question of how to create and produce platform chemicals (e.g. lactic acid) from biomass. Using special microorganism cultures and their optimal supply of trace nutrients, as well as by the use of buffer substances, will facilitate platform chemicals to form during the ensiling process. We will further examine under which conditions carboxylic acids (mainly lactic acid) can be produced in the highest concentrations with different starting substrates (maize, amaranth, grass, rye). In addition, within the project we aim to develop an efficient and cost-effective technique to separate these valuable components from the biomass (solid-liquid separation by using a hydraulic tincture press), and to extract and stabilize them in further steps.

As part of the project, we will subsequently examine how to develop an appropriate way to recover the energy of the remaining residue after separation. Single-phase (Hohenheim biogas yield test & continuous digestion experiments) and two-phase anaerobic digestion will be conducted while at the same time examining the use of mechanical pretreatment and process auxiliaries. The figure below shows the levels of lactic acid which could be achieved by the respective treatment variant, including specific methane yields of fresh silage compared to the remaining crop residues after the solid-liquid separation of maize.

Funding:
Federal Ministry of Education and Research (BMBF)

Partners:
Fraunhofer IGB

IS-Forschung GmbH

Geltz-Umwelttechnologie GmbH

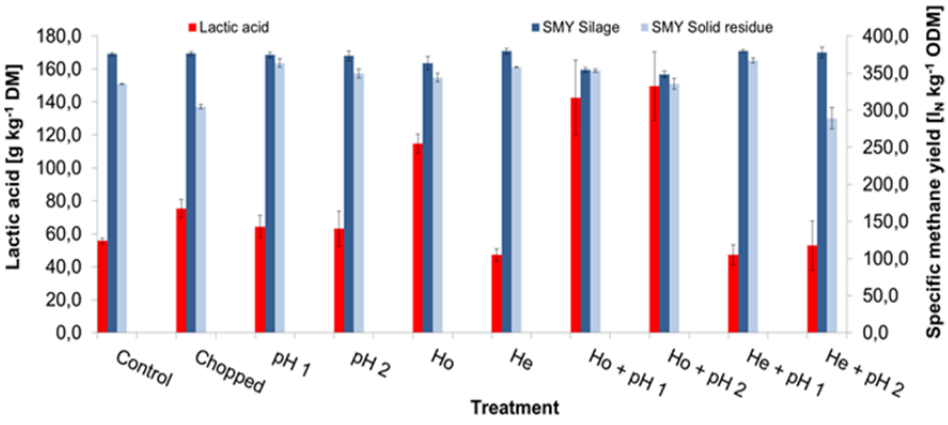
University of Hohenheim, Institute of Agricultural Engineering, Agricultural Engineering in the Tropics and Subtropics

University of Hohenheim, Institute of Crop Science, Biobased Products and Energy Crops

Agentur für nachhaltige Nutzung von Agrarlandschaften (ANNA)

Genedata Bioinformatik GmbH (GDM)

Project duration:
June 2013 – Dec. 2016



Lactic acid content and specific methane yield of grass silage variants

Development of efficient two-phase anaerobic digestion plants via coupled energetic and material utilisation (Optigär)

The overall objective of this project is to develop a procedure for a cascade use and thereby a sustainable and integral utilisation of agricultural raw materials. In this procedure, organic acids with a high economic value are in focus.

In this project, a new concept will be developed for the integrated material use of two-phase biogas plants. This approach will enable a coupled material and energetic use of agricultural raw materials. Different process parameters such as temperature, organic loading rate, pH-value and buffering capacity, the addition of various additives (enzymes, microorganism cultures, buffer substances) and a specific feed material selection, will be tested to increase the concentration of usable platform chemicals in the hydrolysis process. The produced hydrolysate will then be treated with selective membranes to separate valuable products. Process residues will be recycled in anaerobic digestion.

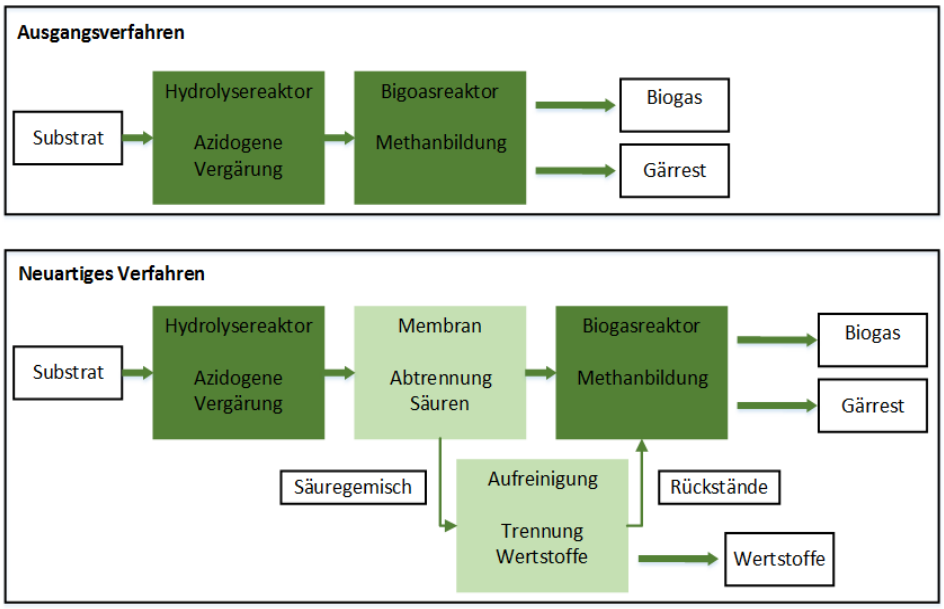
To optimize the yields of valuable substances, there will be both a screening of a variety of agri-cultural raw materials and of the different reaction conditions. The aim is to select suitable substrates and appropriate hydrolysis reaction conditions. For process control, the fermentation products are regularly analysed by wet chemistry analysis.

The Fraunhofer Institute for Chemical Technology (ICT) will separat valuable organic acids via special membranes. To achieve a fully integrated process flow, the separation unit will be integrated into the fermenter chain.

In addition, the European Institute for Energy Research and Lipp GmbH will perform a profitability assessment and a life cycle assessment as well as developing a concept for industrial scale production.

B. Sc. Jörg Steinbrenner

Dr. sc. agr. Hans Oechsner



Standard two-phase anaerobic digestion and a new procedure with coupled separation of valuable substances and biogas production

Funding:
Fachagentur Nachwachsende Rohstoffe (FNR)

Partners:
Frauenhofer Institute for Chemical Technology (ICT)

EiFER European Institute for Energy Research

Lipp GmbH

Project duration:
Sep. 2015 – Aug. 2018

Optimized substrate management and how the composition of biogas digestate influences soil-nitrogen and soil-humus balance

M. Sc. Natali Böttcher

Dr. sc. agr. Hans Oechsner

The composition of the biogas digestate can very widely depending on the subsrate that is fed into the biogas plant. This can also mean that there is a variety of different fertilization effects by different biogas digestates. Whether there is an influence of pretreating the digestate before fertilizing has not yet been studied. As many plant operators lack storage capacity during the Winter months, a time when fertilizing the fields is prohibited, it has become common practise to fertilize in Autumn. As many plant operators lack storage capacity during the Winter months, a time when fertilizing the fields is prohibited, it has become common practise to fertilize in Autumn. This means, however, that digestate is lost on a season where the nitrogen demand of the soils is very low and should be available in Spring when nitrogen demand is high.

The scope of the project is to create a molecular chemical characterization of specific biogas digestates with stable 15N isotopes tracers and subsequently evaluate their different fertilization effects. In addition, the project will also investigate how nitrogen fractions are affected within the reactor during the biogas process. Lastly, plant operators will be provided with suitable guidance for optimizing the fertilization effect.

To achieve this, different research trials are carried out at the state institute for agricultural engineering and bioenergy, which include labelling specific biogas digestates with isotopic 15N-Nitrogen, analyzing the influence on the digestate composition and also investigating the release of nitrogen during the gas production process. For this project, maize, ryegrass and sugar root have been labeled with 15-N-Nitrogen in the greenhouse and subsequently fermented in a Fed-Batch system. To investigate nitrogen release during the process, the nitrogen fractions will be separated and analyzed with an infrared mass spectrometer. Following this, the digestate will be analyzed after separting solids and liquids, and furthermore fertilized within a vessel experiment to see the different fertilizing effects.

Funding:
Fachagentur für Nachwachsende Rohstoffe (FNR)

Partners:
University of Hohenheim
Institute of Crop Science, Fertilization and Soil Matter Dynamics (340i)

University of Rostock
Professorship of soil science

Steinbeis Research Center (SFZ)

Project duration:
01.11.2014 - 30.10.2017

BMP-test in 2 l scale in fed batch mode

The influence of storage temperature and residence time in the biogas fermenter on the inactivation of weed seeds

M. Sc. Pascal Knödler

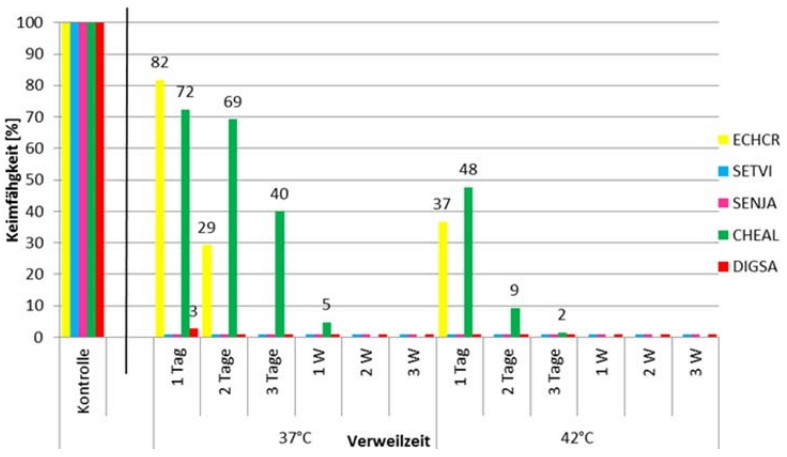
Prof. Dr. Roland Gerhards

Dr. sc. agr. Hans Oechsner

Maize is the most common plant material used in agricultural biogas plants. Along with grasses, maize can play host to up to a large number of weeds. The seeds of these weeds can then be assimilated into the biogas plant together with the crop. Even though there may be sufficient numbers of viable seeds present in the soil and even dispersed by some weeds before harvesting, the biogas process still requires that seeds be destroyed when coming into contact with the fermenter. This will therefore prevent any additional accumulation on fertilized surfaces that contain digestate.

The scope of this project was to investigate the circumstances under which different weed seeds are inactivated in the fermenter. As seen in previous experiments, there is a close relationship between weed species, the temperature in the fermenter and the residence time of the seeds in this environment. This investigation chose to look at particularly robust species that are able to survive for a long time in the soil and those that are commonly found amongst maize. The species selected are Amaranthus retroflexus (red-root amaranth), Chenopodium album (goosefoot), Digitaria sanguinalis (hairy crabgrass), Echinochloa crus-galli (cockspur grass), Sencio jacobaea (ragwort) and Setaria viridis (green foxtail). The seeds were sewn into a cotton bag and placed into a fermenter at different operating temperatures (37°C, 42°C and 52°C). The seeds were left in the fermenter for a period of 2 to 24 hours for the thermophilic temperature of 52°C and between 1 and 21 days for the other mesophilic temperatures. The seeds were then examined, in cooperation with herbology department of the Institute of Phytomedicine, for germination capacity using a germination test specified by ISTA (International Seed Testing Association).

The results of this investigation had shown that most of the seeds were inactivated at temperatures of 37°C after a residence time of one day. A substantial number of seeds from cockspur grass and goosefoot did, however, survive the first day with temperatures of 37°C. Even after one week, the seeds of goosefoot were not yet completely inactivated. Despite the seeds of goosefoot surviving for up to three days, temperatures of 42°C had accelerated the inactivation process. A rapid reduction in germination capacity was seen in variants that had been exposed to thermophilic temperatures. All seeds were inactivated by the 24 hour mark. This project has therefore demonstrated that the biogas process has the ability to substantially reduce weed pressure.



Significantly inactivation of weed seeds at mesophilic digestion temperature

Funding:
Ministry for rural environment and consumer safety Baden-Württemberg

Partners:
University of Hohenheim
Institute of Phytomedicine Fg. Herbology (360b)

Effect of TE application on bio-methane yield and process stability of digestion of coffee pulp and husk

M.Sc. Bilhate L. Chala

Prof. Joachim Müller

Dr. sc. agr. Hans Oechsner

Ethiopia is the birth place for Coffea Arabica. Coffee production has vital economic and cultural implications and nearly a fifth of the population are dependent on producing coffee for their livelihood in Ethiopia.

Primary coffee processing happens mostly in developing countries and produces green coffee bean both for domestic and export purposes. However, the process produces a large amount of biomass as by-product (pulp, husk, mucilage and parchment) which is subsequently dumped without any use. This creates significant environmental and social problems.

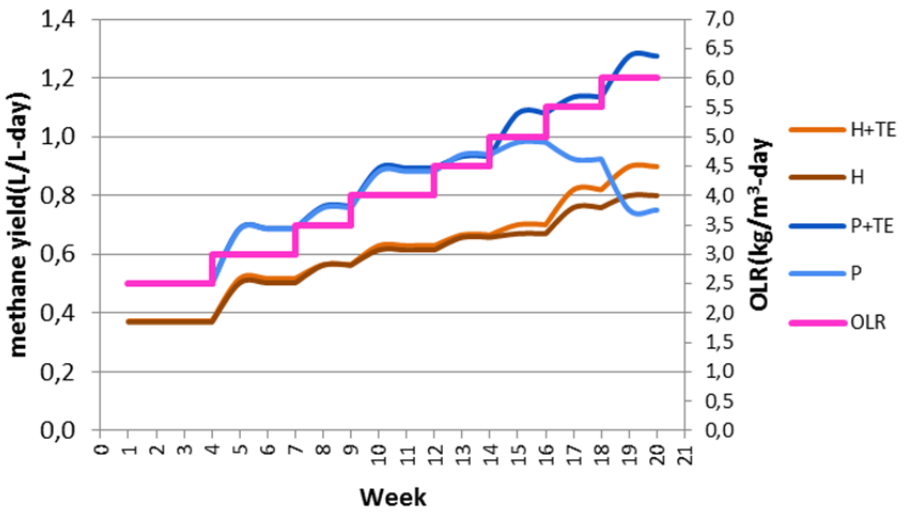
The bio-methane yield potential was examined with HBT and was found to be promising for all by-products except parchment. The methane yield during digestion at 37°C of pulp, husk and mucilage was 0.245, 0.159 and 0.294 m_N^3/kg_{oDM} respectively.

The elemental analysis of coffee pulp and husk indicated that both substrates lack important trace elements (TE) like manganese, zinc, cobalt, molybdenum, iron, nickel, selenium, and tungsten; which are critical for stable anaerobic fermentation in continuous mono-digestion systems.

The bio-methane production performance for digesters fed with pulp and husk, with and without the application of trace elements, was evaluated in duplicate 20L volume CSTR reactors for 20 weeks. The organic loading rate started at 2.5 kg_{oDM}/m^3 d and gradually increased upto 6 kg_{oDM}/m^3 d.

The average stable methane productivity from-fed pulp containing digesters with and without TE was 1.3 m^3/m^3 d and 1 m^3/m^3 d for OLR of 6 kg_{oDM}/m^3 d and 5 kg_{oDM}/m^3 d, respectively. Similarily, the productivity of the husk with and without TE was 0.9 m^3/m^3 d and 0.8 m^3/m^3 d, respectively, with an OLR of 6 kg_{oDM}/m^3 d.

In comparison to their counterparts without TE, digesters with TE were found to be more stable with consideration to VFA and FOS/TAC values pulp and husk substrates. In addition, the bio-methane yield was also superior for digesters containing TE. Moreover, TE application favours a higher organic loading rate for digesters containing pulp.



Methane productivity of pulp and husk with and without application of trace elements (TE), with different OLR

Funding:
GlobE BiomassWeb project

Partners:
University of Hohenheim
Institute of Agricultural Engineering
Agricultural Engineering in the Tropics and Subtropics (440e)

Evaluating how veterinary drugs interfere with anaerobic digestion of agricultural and livestock wastes

M. Sc. chem. Ricardo Luís Radis Steinmetz

Prof. Dr. chem. eng. Hugo Moreira Soares

Prof. Dr. med. vet. Ludwig E. Hölzle

Dr. sc. agr. Hans Oechsner

Antibiotics are used globally in food-production animals as a therapeutic treatment of specific diseases and as a sub-therapeutic treatment to prevent infection. In some countries (eg. Brazil) they are also frequently mixed into feedstuffs as a growth promoter. It is known that a significant fraction of the administrated antibiotics are excreted in the parent form or its metabolites (30 to 90%) and the residual content in manure could inhibit anaerobic digestion in the biogas process.

On the other hand, anaerobic digestion is the main alternative to treat the manure. Moreover, the possibility to improve the biogas production by co-digestion with agricultural substrates is a good strategy to improve the biogas market and livestock sustainability in developing countries.

This project was proposed to promote a better understanding on how veterinary drugs may interfere in biogas production by co-digestion of manure with agricultural substrates. Experiments were performed using an inhibition test scheme by adding a wide range of tylosin, tiamulin, lincomycin and gentamicin in anaerobic digestion of agricultural standards substrates in an HBT system.

Significant inhibition in biogas and methane production was observed after 3 days of experiment in order: tylosin ~ lincomycin > tiamulin >> gentamicin. Losses in the biogas yield (after 35 days) were higher for lincomycin and tiamulin. In general, the inhibition effect was lower than 10% in concentration levels than expected in swine manure, indicating that no significant interference could be estimated in the biogas plant. However, VFAs (acetic, propionic, butyric, iso-butiric and iso-valeric) which had accumulated during the process could lead to the hypothesis that these drugs produce a somatic or synergic effect in others inhibitory mechanisms (eg.: overloading). Further supplementary studies will shed light on how veterinary drugs may have an effect on anaerobic microorganisms.

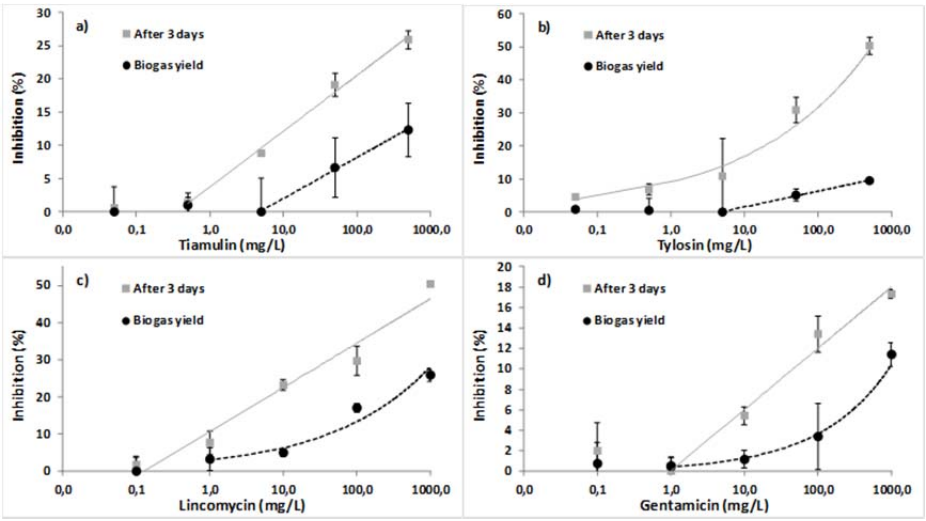
Funding:
Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA)

Partners:
Brazilian Agricultural Research Corporation (Embrapa)

Federal University of Santa Catarina (UFSC)

Institute of Animal Science - University of Hohenheim

Project Duration:
11.09.2015 - 26.12.2015



Inhibition (dose-response) of tiamulin,tylosin, lincomycin and gentamicin in biogas production of concentrated feedstuff standard

Acquisition of major research equipment „Biogas-BHKW”

On behalf on the rectorate, the state institute has aquired the operational management and coordination of research projects at the research biogas plant “Unterer Lindenhof”. Large scale research equipment of the research biogas plant is owned by the University of Hohenheim and is operated under the experimental stations of agricultural sciences. In the year 2015, the biogas plant used a daily average of 9.7 t of liquid and solid manure from on-site animal husbandry, 7.8 t of renewable raw materials, and 1.1 t of raw horse manure for biogas production. By utilizing the biogas in a combined heat and power plant (CHP), the biogas plant was able to provide the district heating network for the location of “Lindenhof” with 1.52 million kWh of electricity and 1.04 million kWh of heating. The high number of experiments carried out for research as well as the large number of international visitors has demonstrated the relevance of this major research facility.

Dr. sc. agr. Andreas Lemmer

Dr. sc. agr. Hans-Joachim Nägele

Substantial preporatory work has been done in 2015 in order to optimize the technical ability of the plant and to adapt to changing conditions. In particular, a new German Renewable Energy Act has required that CHP-units at biogas plants have to become more flexible by supplying heat and electricity under a demand-based approach. In 2015, building permit for installing the new CHP was applied for and finally granted by the municipality Eningen. A further achievement was the application and approval of three new, experimenal mobile-silos which were funded for under the FNR research project This was followed by enabling necessary technical procedures towards replacing the medium-voltage main distribution board and the transformer of the CHP-unit to deal with a more powerful CHP installation. As a result, Lindenhof would be able to supply its own electricty from the biogas plant.

The new biogas-CHP is set to replace the existing electrical output of 186 kW with a maximum electrical outpout of 350 kW. The new procedural challenges now include steps towards load cycling, intergrating into virtual power plants, demand-based electricity production and using exhaust gas heat to produce electricity. Investigating how these new procedures may impact efficiency, emissions, maintenance costs and downtime provides new research fields that can be explored in combination with the newly aquired CHP-biogas plant and the research biogas plant.

Research biogas plant digesters with mechanical substrate pretreatment

Funding:
University of Hohenheim

Project duration:
Applied for 2014 - Implementation 2016

The chemistry laboratory of the state institute of agricultural engineering and bioenergy

Dipl.-Biol. Annette Buschmann

Christine Baur

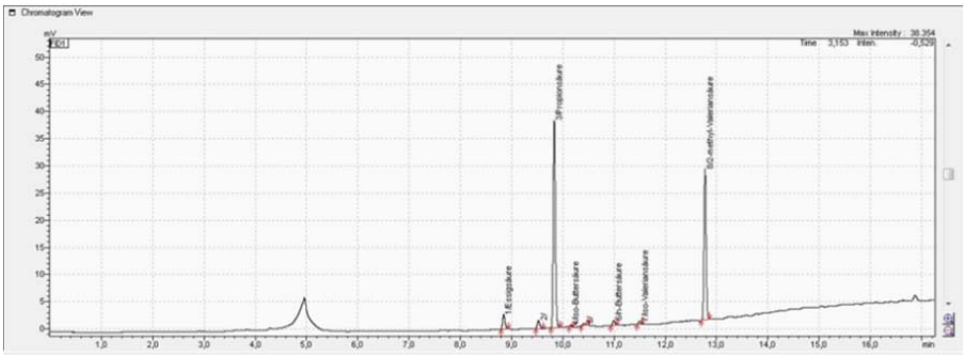
Inga Buschmann

The chemistry laboratory analyses different nutrient compositions and determines important parameters which are required for the analysis and evaluation of degradation processes that take place in biogas plants. Laboratory analytics have been continuously refined in the last few years due to the modern equipment procured by the university and external funding. An analytical focus has been assigned into researching technical processes and biological efficiency of the biogas process. The equipment and evaluating methods that are currently on hand are

- two gas chromatographs (GC) to determine the concentration of volatile fatty acids in the digester substrate, an important parameter for assessing the biological stability of the biogas process,
- a high pressure liquid chromatograph (HLPC) that is able to analyze fatty acids (incl. lactic acid), alcohols as metabolites of the biogas process, and especially non-volatile compounds, such as various sugars,
- a fully automated titration system for determining the buffer capacity of the digester content,
- a powerful analyzer for simultaneous analysis of total carbon (TC), total inorganic carbon (TIC) and total nitrogen (TN) in aqueous samples plus the TC content in solid samples
- a digestion and distillation system to determine total nitrogen and ammonium nitrogen in both aqueous and solid samples in agreement with the Kjeldahl method.

All equipment are fitted with automatic samplers which are able to perform a fully automatic determination thereby greatly increasing sample throughput. The wide analysis spectrum of each device has enabled selected parameters such as volatile fatty acids or total nitrogen content to be determined automatically by means of different methods. This means that there is a direct control and internal validation of measurement results which contributes to quality assurance of analytic results. Further advantages include improved balances of processes.

An expansion in space and staff in the chemistry laboratory has also been running parallel to procuring more equipment. While before there was just a room that was shared with the institute of agricultural engineering, the chemistry laboratories of the state institute have now acquired three rooms. One full-time and two part-time staff members perform the analyses of the samples obtained. The team is additionally supported by university student assistants and school students who obtain, during their internship, theoretical and practical insights into the daily lab life.



Chromatogram of GC analysis of a fermenter sample taken from the biogas plant "Unterer Lindenhof"

Co-organized Conferences

- **ALB symposium - „Milchviehhaltung“**
  5. March 2015
  University of Hohenheim, Stuttgart, organisd together with ALB Baden-Württemberg
- **ALB specialist event - „Mehr Tierwohl – der baden-württembergische Weg“**
  25. March 2015
  Schwäbisch Hall-Veinau, organisd together with ALB Baden-Württemberg
- **ALB Expert discussion - „Neue Richtlinien zur Lagerung von Gülle, Jauche, Silagesickersaft“**
  26. November 2015
  Erbach-Dellmensingen, organisd together with ALB Baden-Württemberg
- **International Biogas & AD Training Course**
  13.-17 April 2015
  Stuttgart, University of Hohenheim, organisd together with IBBK
- **International Biogas & AD Training Course**
  14.-18. September 2015
  Stuttgart, University of Hohenheim, organisd together with IBBK

International Guest Scientists to the State Institute

- **Ricardo Luís Radis Steinmetz**
  “Evaluation of veterinary drugs interference in anaerobic digestion of agricultural and livestock wastes”
  Brazilian Agricultural Research Corporation (EMBRAPA)
  Brasilien
- **Aida Sandybaeva**
  „Influence of magnetic fields on the kinetics of biogas production“
  Technical State University named by I.Razzakov
  Kirgistan
- **Elena Kobiakova (Елена Кобякова)**
  „Possibilities of application biogas technology for processing of cattle manure in the Republic of Sakha (Ya-kutia)“
  East-Siberia State University of Technology and Management
  Russian Federation
- **Bilhate L. Chala**
  “Effect of TE application on bio-methane yield and process stability of digestion of coffee pulp and husk”
  University of Hohenheim, Institute of Agricultural Engineering, Agricultural Engineering in the Tropics and Subtropics (440e)

Social Media

Dr. sc. agr. Hans-Joachim Nägele
Creation of the website: http://www.bioenergieforschungsplattform-bw.de
commissioned by the Ministry of Rural Affairs and Consumer Protection Baden-Württemberg

Graduate Theses 2015

Doctoral Theses

Nicola Loenard Haag
Production of lactic acid and methane from renewable resources - an innovative green biorefinery concept for biogas process chains. Dissertation, Universität Hohenheim.
http://opus.uni-hohenheim.de/volltexte/2016/1165/pdf/20151221_Dissertation_Haag.pdf

Jonas Lindner
The effect of enzyme additives on the anaerobic digestion of energy crops. Dissertation, Universität Hohenheim.

Staff of the State Institute who partake in a doctorate within the faculty of agricultural sciences are scientifically supervised by the Senior Head of the State Institute, Prof. Dr. Thomas Jungbluth.

Master Theses

Pascal Knödler
Influence of digestion temperature and time on the mortality of selected weed seeds in the biogas process

Colin Kohler
Optimizing the biological methanation process of hydrogen with regards to entry technique

Roman Schindler
Municipal waste treatment in urban areas: A case study on large-scale biogas production in Nakhon Ratchasima

Sabine Schmitz
A study on the co-digestion of solid wastes by comparing degradation kinetics and accessibility of organic matter

Stephan Ruile
Mixing quality of the fermentation substrate in the biogas fermenter depending on the ruhr intensity: investigations at the praxis scale in the research biogas plant Unterer Lindenhof

Ralf Löx
Mechanical crushing and enzymatic (Lentinula edodes) digestion of separated digestate towards increasing overall methane yield

Nabil Faouzi
Mechanical crushing and enzymatic (Lentinula edodes) digestion of separated digestate towards increasing overall methane yield

Bachelor Theses

Jochen Gräber
Construction and trial of a test stand for online measurement of organic acid concentrations by means of an acoustic waveguide

Fabian Hohner
Investigating the drying of fermentation residues with CHP exhaust gases

Tobias Zeh
Investigating the biological methanisation of hydrogen

Julian Veit
Analysis of the biogas potential of residual material from field vegetable production in the Filder region

Project Work

Lukas Illi
A mass balance for the two-stage fermentation of different substrates

Karsten Luff
A mass balance for the two-stage fermentation of different substrates

Sebastian Bing
Investigations of anaerobic degradation of fruit and vegetable waste in a two-stage system

Sinem Karagöz
Investigations of anaerobic degradation of fruit and vegetable waste in a two-stage system

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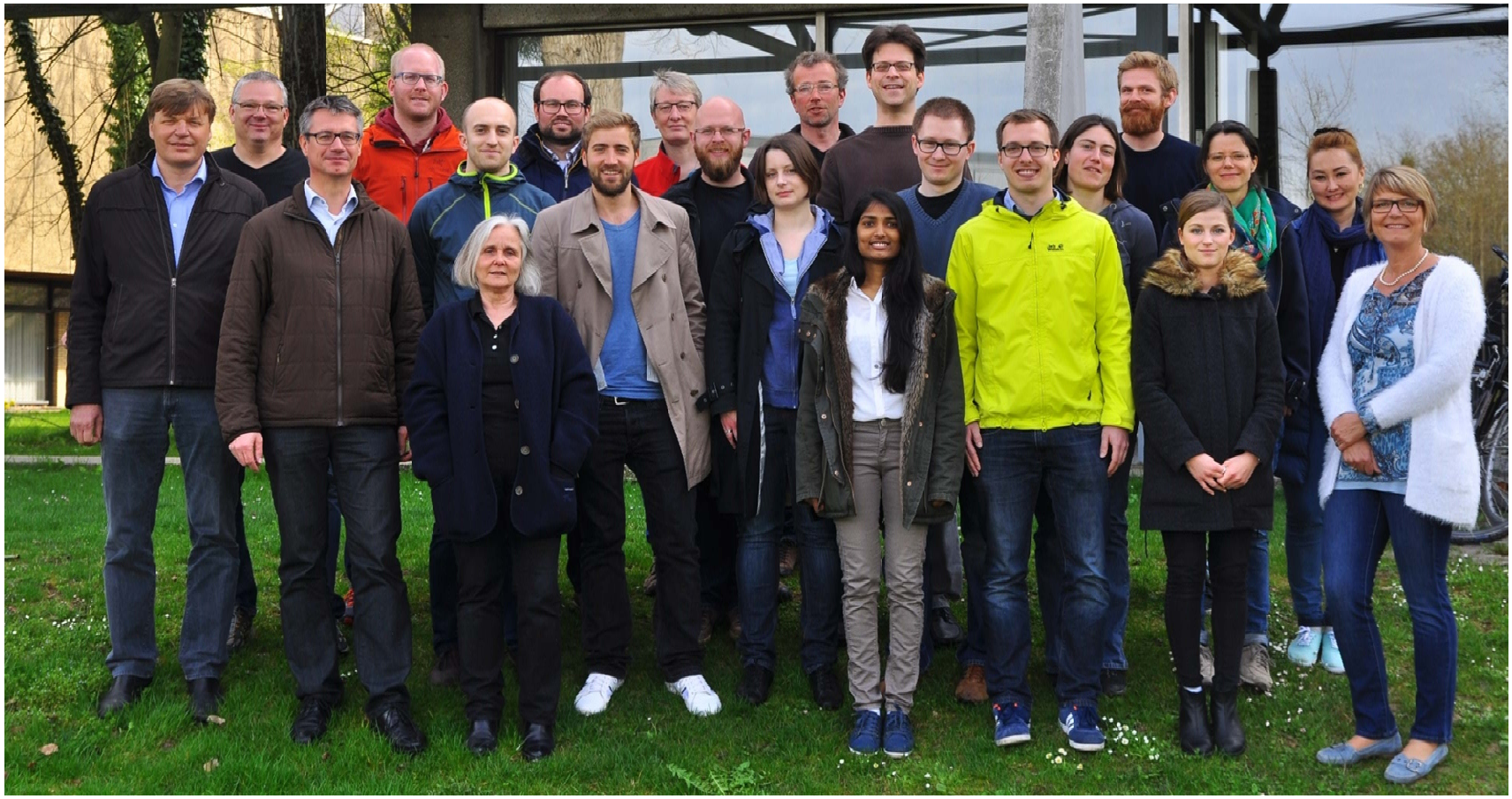

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