Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ






ANNUAL REPORT 2016

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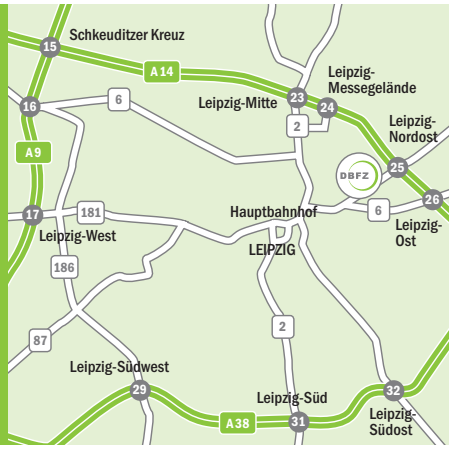

DIRECTIONS

By train: to Leipzig main station. Take tram line 3/3E (towards Taucha/Sommerfeld) as far as the Bautzner Strasse stop. Cross over the road, passing the car park on the right, and turn right through gate number 116, after approximately 100 metres turn left, the DBFZ entrance is 60 metres further along on the left-hand side.

By car: on the A14 motorway. Exit at Leipzig Nord-Ost; follow signs for Taucha; then follow signs for Leipzig; then follow signs for Zentrum, Innenstadt. Turn off left after the "bft" filling station (see "By train" for further directions).

By tram: line 3/3E towards Taucha/Sommerfeld; Bautzner Strasse stop (see "By train" for further directions).

ANNUAL REPORT 2016

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1 PREFACE BY THE MANAGEMENT

Dear Reader,

2016 was a very intensive year for us and our scientific work. As a research institute, we enjoyed a number of highlights on a variety of different levels. In scientific terms, this includs the acquisition of new projects involving DBFZ shares between one and over four million euros. The key area of policy advice has also been further strengthened and expanded through numerous surveys and background documents (such as a position paper on the German federal government's climate protection programme). Despite being a still relatively young research institute, we have become a voice which is taken seriously by politicians in Berlin in all matters relating to bioenergy.

Wide-ranging intensive networking activities have helped strengthen our research contacts on a national and international level. Our involvement in many EU consortia, numerous keynote papers at leading bioenergy conferences and our co-hosting of conference events in China and India have boosted that positive trend. We are particularly delighted that the long-running construction works on our new technical centre and on the office and events building are now finally taking on recognisable forms. On August 31, 2016 we laid the foundation stone for the new building in the presence of the Federal Minister of Food and Agriculture Christian Schmidt, Governor of the state of Saxony Stanislaw Tillich, State Secretary Gunther Adler and the Leipzig City Councillor responsible for economy and employment, Uwe Albrecht. This represented a major step in the long-term development of our research focus areas.

We would like to warmly thank all those who have supported us (shareholders, the Supervisory Board, the Research Advisory Council, governmental ministries, project funding bodies, and all project partners). Your sustained support in all aspects of our scientific work is a great help to us on the not always easy path through the transition to renewable energy.

Prof. Dr. mont. Michael Nelles
Scientific Managing Director

Daniel Mayer
Administrative Managing Director

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INNOVATIVE RESEARCH FOR A CLEAN ENVIRONMENT

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Fig. 1 **The goal of the “Catalytic emission control” research focus area is the clean inceneration of solid biomass**

Some 12 million stoves were heated by firewood, the oldest form of energy production, in Germany in 2016. Representing 23 percent of the total, this form plays a key role in the provision of heat from renewable energy sources. Wood from sustainable forestry is also classed as a virtually CO_2-neutral energy source, and as such it can contribute greatly to reducing greenhouse gases. Nevertheless, some 30 percent of dust emissions from energy production originate from mostly domestic stoves. This impacts not only on the environment, but also human health. In the “Catalytic emission control” research focus area, DBFZ scientists have been intensively working on the reduction of pollutant gases from the incineration of solid biomass and other renewable energy sources since 2011. The goal is to significantly reduce the health risks from the incineration of solid biomasses, beyond the existing state of the art, based on technical optimisation of stoves as well as by adapting incineration processes. In April 2016, DBFZ scientists took part in a firing competition at the Brookhaven National Laboratory in Upton, New York, USA

Fig. 2 **DBFZ report no. 27 "New-style low-emission stove (DBU NEKO)"**

organised by the Alliance for Green Heat with the "Pellwood" experimental combination stove model developed in cooperation with the private companies, SL Systemlösung Haustechnik GmbH and Specht Modulare Ofensysteme GmbH & Co. KG. The team headed by Dr. Ingo Hartmann scored highly in all categories of the Pellet Stove Design Challenge, emerging ahead of its 11 competitors in the overall ranking.

THE RESEARCH FOCUS AREA "CATALYTIC EMISSION CONTROL"

The DBFZ's "Catalytic emission control" research focus area conducts intensive research and development work to reduce emission from incinerators by catalytic methods. To that end, since 2010, it has set up a number of reactors and technical test beds for activity measurements of post-combustion catalysts, using them to conduct numerous measurements as part of project and contract works. The available technical capacities enable the development and characterisation of catalysts with complex modelled and real waste gases from incinerators. Additionally, a mobile trailer-mounted flow metering apparatus is deployed for activity measurement on-site at incinerators. This mobile system has been in use since August 2013, including ageing and deactivation measurements with waste gas from actual application cases.

2.1
INTERVIEW WITH DR. INGO HARTMANN

Dr. Hartmann, in April 2016, your "Pellwood" stove prototype won the prestigious Pellet Stove Design Challenge in the USA. What makes your stove unique?

Ingo Hartmann: In technical terms, the Pellwood is a conventional firewood-burning stove, with an additional facility to burn pellets. This special technique means, the reaction in the flame, when possible, initially occurs completely inside the stove's combustion chamber, and then the waste gas is discharged by way of a catalyst for fine-cleaning. The incineration is a three-step process. In the first step, the wood pellets are pyrolytically decomposed – that is, disintegrated by heat – and converted into fuel gas. In the second step, the gas is oxidised as fully as possible. The third step then involves complete burn-out, heat transfer, and fine-cleaning of the pollutants by the catalysts. Among other benefits, this special technique enables harmful emissions such as dust and carbon monoxide to be minimised. Users burning firewood can also enjoy an attractive flame pattern.

So is the combination of firewood and pellets particularly efficient and environmentally friendly?

Ingo Hartmann: People love gazing into a flickering wood fire. That is unlikely to change. Our aim was to meet that traditional need, while making the stove very low-emission. The Pellwood is equipped with a ready-made pellet burner. As opposed to firewood, pellets have a very high energy content, and can be burned in a much more user-friendly way, also generating fewer emissions. The principle on which the stove is based is that the users' heat requirement is first met by pellets, and subsequently the firewood creates an attractive flame pattern.

What were the challenges in developing the stove?

Ingo Hartmann: Wood can only be used for heating in a climate-neutral way if the installations are efficient and clean. That is why our primary goal was to develop the experimental stove optimally as a fundamental model. In the initial research phase, our work was focused on optimising the combustion chamber. Thereafter, the challenge was to balance the experimental stove and the catalysts precisely to each other, and that has indeed taken several years. We can now say that we are well on the way to achieving it. That claim is backed by our victory in the USA, which we were of course delighted about. Continuing on from the basic research, in the development phase we are now conducting practical trials and taking into account safety aspects too. Moreover, the design has to be adapted to end-users' needs, and the stove systems have to be scaled to modern homes with low heat-demand. But our primary concern is to make the stoves flexible and to integrate them intelligently into domestic heating systems.

Will the Pellwood stove be automatically controlled according to heat demand?

Ingo Hartmann: Yes, that is essentially the goal. By automatically integrating the stove into a complex heating system, the heat can be drawn out of the stove by way of water tanks, stored in a buffer, and then intelligently distributed around the home. This means our SmartBiomassHeat concept, which to date has been theoretical, will be implemented in an innovative, future-proof actual product. In our trials, the system has already successfully demonstrated that heat demand can be met in a low-emission way by the pellet burner component. Our current and future work involves the development of a calculation and information tool, telling users how much wood to place on the stove for the most beneficial heating.

Experts estimate annual sales of some 300,000 new stoves a year in Germany. How far is your "Pellwood" prototype from market maturity?

Ingo Hartmann: We already have a number of enquiries from end-user customers and companies who are very interested in the stove and the technique it employs. Our original plan was to bring the stove to market by the end of 2017. However, we

Fig. 3 Presentation of prize to the Wittus team including the collaboration of the DBFZ (René Bindig, centre)

still have some research work to do as part of a follow-up project. The pellet burner is going to have to be completely redesigned in order to meet the challenge of operating in a stove and reducing heat output in accordance with a single-chamber furnace.

Will the stove system you develop be available at an affordable price?

Ingo Hartmann: "Affordable" is of course a relative term. A high-tech stove will doubtless cost more than a model bought at a DIY centre. The prices of currently available stoves range from 200 up to about 4,000 euros. Our Pellwood model

Fig. 4 The right catalysts can significantly reduce harmful emissions

will be more towards the upper end of the range, though no price has yet been specified. Our research is also demonstrating, however, that there is no need to install an expensive stove in order to obtain virtually zero-emission heating. One of the key aspects of our development is the catalyst technology. When adapted accordingly, it will work in a low-cost stove just as well as in a high-end model.

What can ordinary stove owners do themselves to avoid harmful emissions from their heating systems?

Ingo Hartmann: Dust, soot and carbon monoxide cannot be entirely avoided in conventional stoves without secondary measures installed. Nevertheless, correct user behaviour does indeed have a major influence when it comes to avoiding airborne pollutants. There are a number of points that stove-owners need to consider in order to minimise harmful emissions from domestic stoves used for heating. They include, for example, using the right lighting method. Instead of paper, it is advisable to use wood-wool or professionally made fire-lighters. Also, the wood should have been left to dry for an adequate amount of time before being lit. Another vital consideration is to ensure that the stove is kept technically up-to-date. Many domestic stoves are very old, and often have not been checked and serviced for decades. It is advisable to consult a professional on this. In many cases a chimney sweeper can provide valuable advice.

The German Federal Immission Control Regulation (1. BImSchV) in 2010 was a key statutory measure in limiting harmful emissions from domestic stoves. How are outdated stoves still allowed to be operated at all?

Ingo Hartmann: The Regulation had a major impact on the whole industry, especially stove manufacturers. The second stage of 1. BImSchV, introduced in early 2016, further tightened the existing emission limits substantially; as a result of this many domestic stoves had to be upgraded or, depending on age, completely replaced. This approach does come up against a number of obstacles in practice however. For example, a lot of education and explanation is still needed to convince consumers to focus on the benefits of improved energy efficiency and reduced emissions rather than the supposedly high replacement cost. The process has generally been slow to date, and it is likely to take quite a while longer in view of the lengthy transition periods allowed by the law.

Can the problem of harmful emissions from domestic small-scale furnaces be resolved solely by new stoves?

Ingo Hartmann: Yes and no. We are talking about future developments in stove technology here. Current “state-of-the-art” stoves are not necessarily better than those on the market 20 or 30 years ago. When it comes very low-cost stoves,

optimised for the test bed, I am highly sceptical. In the next two to three years, the industry and we scientists are going to have to do lots of development work. To be honest, in a lot of cases, existing technology is being copied and sold to consumers as new. So it is essential to ensure that old stoves really are replaced by models which are verifiably low-emission and new. Unfortunately, conventional type testing for single-chamber furnaces does not at present always deliver the right indicators for identifying clean stoves under practical conditions.

Fig. 5 Dr. Ingo Hartmann and his team are researching very low-emission stoves

So what do you think is the best approach?

Ingo Hartmann: An appropriate first step would be to improve users' behaviour, and where applicable, to develop and deploy automated systems. Also, stove manufacturers have to be serious about driving forward developments, so as to improve emissions in practical operations too. So the industry should be investing in new technology, and making type testing more realistic ("Blue Angel", "BeReal"). And chimney sweeper measurements on single-chamber furnaces should be made obligatory.

You have headed the DBFZ's "Catalytic emission control" research focus area for a number of years. Do you monitor emissions from other biomasses in addition to wood?

Ingo Hartmann: We research the use of biomass as an energy source and its "side effects" in five different focus areas. There are of course lots of thematic points of intersection. Alongside the conventional biomass incineration processes using firewood, we also investigate the emissions of liquid and gaseous energy source materials such as biodiesel and biogas for example. In cooperation with the "Processes for chemical bioenergy sources and fuels" research focus, for example, we are conducting special research into catalyst ageing on an engine test bed. Within the "Anaerobic processes" research focus, extensive research is being conducted to develop an oxidation catalyst for methane. Whether – and to what extent – the use of catalysts in biomass incineration processes is sustainable is being investigated in conjunction with the "System contribution of biomass" research focus. And finally, the "Intelligent biomass heating technologies" (SmartBiomassHeat) research focus is working to make heat production from wood-type solid and alternative biomass more flexible. Here, too, work is being carried out in close cooperation with the "Catalytic emission control" research focus area.

In profile

Dr. Ingo Hartmann is a scientist in the DBFZ's Thermo-Chemical Conversion department and head of the "Catalytic emission control" research focus area. Since 2008, he has also been a lecturer at the Leipzig University of Applied Sciences (HTWK), where he has lectured on the construction of thermal apparatus and environmental technology and head of the DBFZ Small-scale Furnace Systems working group. In 2014 the spin-off company ETE EmTechEngineering GmbH was established, in which Dr. Ingo Hartmann is one of three shareholders.

Additional information:
www.smartbiomassheat.com
www.dbfz.de/en/publications/dbfz-reports
www.dbfz.de/en/focus-areas/catalytic-emssion-control

3
RESEARCH FOCUS AREAS

With its wide-ranging applications (electricity, heat, motor fuels), biomass is the oldest and most versatile renewable energy resource. It also provides building materials and primary materials for the chemical industry, and as such plays a major role in integrating material usage within a bioeconomy. The task of integrating biomass into the existing energy system does, however, face many challenges, as well as technical and ethical questions, such as: how can energy efficiency be improved; how can competing usages be overcome; how can emission of the soil, water and air be avoided; and how can – and must – the 'smart' bioenergy of the future be shaped?

These and many other questions are expertly and independently investigated and answered by the DBFZ (German Biomass Research Centre). The mission of the scientists at the DBFZ is to develop technical solutions and devise wide-ranging concepts for the economically, ecologically and socially sustainable use of biomass as an energy source based on applied leading-edge research. The DBFZ also investigates and predicts potential areas of conflict between the various goals associated with the development of bioenergy, setting forth plans as to how such conflicts can be avoided and eliminated. The DBFZ's research work seeks to

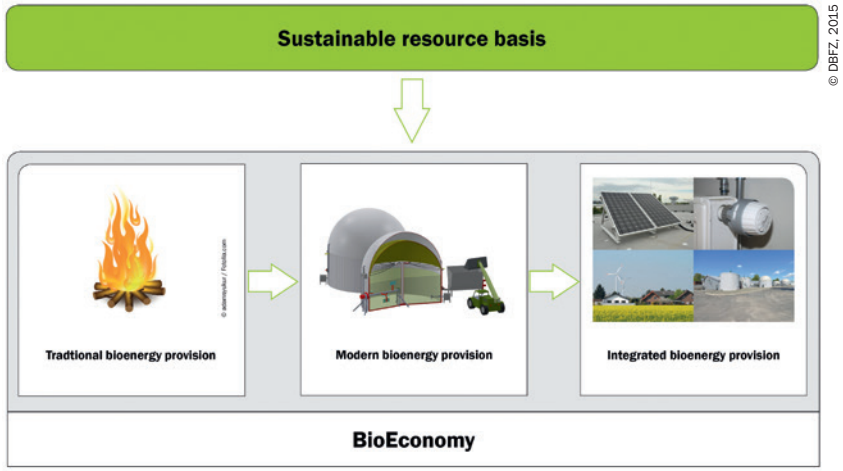

Fig. 6 Development stages for integrated smart bioenergy supply

Fig. 7 Applied biomass research at the DBFZ's fuel conditioning and combustion lab

expand knowledge in relation to the scope and limitations of biogenic resources as an energy source and integrated raw material within a bio-based economy ('bio-economy'). It also aims to safeguard the leading position enjoyed by Germany in the sector for the long term.

THE BIOENERGY RESEARCH FOCUS AREAS AT THE DBFZ

Alongside the four research departments into which the DBFZ is organised, key bioenergy research topics are covered by five interdisciplinary research focus areas. They ensure that key questions and aspects of bioenergy can be mapped and investigated to the depth necessary for excellent research. The research focus areas are oriented to future trends and research policy challenges and background conditions (including the strategies of the German Federal Government, such as the BioEconomy 2030 national research strategy, the National Bioeconomy Policy Strategy, the Federal Government's Mobility and Motor Fuel Strategy, the Biorefineries Roadmap, etc.). Other cornerstones include the conditions dictating grant aid and subsidy policy, unique selling points within the research landscape, and in particular the sound infrastructure of the DBFZ. The following sets out the work of the five research focus areas based on the example of selected reference projects.

Additional information:
www.dbfz.de/en/focus-areas

3.1
SYSTEMIC CONTRIBUTION OF BIOMASS

"As a gaseous energy source material with high energy density, biomethane can play a key role in the energy system of the future. European biomethane trading is restricted by a number of technical and administrative obstacles. Consequently, the EU H2020 'BIOSURF' project is seeking to eliminate obstacles to the sustainable trading of biomethane in Europe."

Stefan Majer, Project Manager

BIOSURF (BIOMETHANE AS SUSTAINABLE AND RENEWABLE FUEL)

Biomethane is gaining in importance as an energy source material within a European context. Various EU member-states (including France, Italy and the UK) have greatly strengthened their efforts to expand their national biomethane sectors in recent years. In view of the often marked differences in the potential and possibilities for biomethane production among EU member-states, European biomethane trading can be an interesting option in the future for achieving national climate protection targets or targets for growth of renewable energy use. Analysing and eliminating obstacles to enhance European trading in sustainably produced biomethane is at the core of the EU H2020 BIOSURF (BIOmethane as SUstainable and Renewable Fuel) project. It involves 11 partners from seven EU countries (Austria, Belgium, France, Germany, Hungary, Italy and the UK), and covers a wide range of focus topics.

A core task of BIOSURF is to analyse various value chains for biomethane production taking into consideration geographical, physical, economic and ecological aspects. Based on the analyses, economic and ecological parameters for biomethane production will be collated from a broad range of substrates (such as residual and waste materials, cultivated biomass, etc.). The project will also consider the use of biomethane in various sectors (biomethane as biofuel in the transport sector, as well as for electricity, heat and cold production).
A further prerequisite for deriving recommendations on how to enhance European biomethane trading is analysis of the existing and varied subsidy policies for biomethane production and its use in the member-states. BIOSURF analyses and compares the existing legislation as well as existing technical standards, registers, labelling and certification systems in the EU member-states. Thanks to its broad-based involvement of scientific partners and market actors, BIOSURF is also supporting the Europe-wide interchange of information and best practice examples, as well as promoting networking and closer cooperation between the partner countries in the project.

SUSTAINABILITY AS A PREREQUISITE FOR SOCIAL ACCEPTANCE OF BIOMETHANE

Key prerequisites for social acceptance of biomethane as an energy source material are the sustainability of the substrates used and adherence to sustainability criteria throughout the biomethane production and use value chain. One of the BIOSURF work packages is therefore devoted to upgrading ecological criteria and quality standards for the quantification of greenhouse gas emissions and reducing indirect land use changes. The results obtained will assist market actors in their greenhouse gas balancing processes in future, and will help derive optimisation strategies, based on identification of the key drivers of CO_2 emissions along the entire value chain.

POTENTIAL FOR BIOMETHANE PRODUCTION FROM WASTE AND RESIDUAL MATERIALS

As part of the project, the DBFZ is involved in compiling a European data base to identify sustainable potential residual and waste materials for biomethane production. This work so far has determined the potential of liquid manure, organic municipal waste, agricultural residues, catch crops and energy crops for biomethane production in a total of six EU member-states. The results of these analyses are detailed in Deliverable 4.2 (see end of chapter).
In Germany, the results for energy crops show the highest theoretical and technical (realistic) potential for the production of bioenergy in biogas plants. The Fachverband Biogas technical association estimates the potential for energy production based on this potential fraction at approximately 108 PJ/a (30 TWh/a) of electricity. Two thirds of that potential is already being utilised for the production

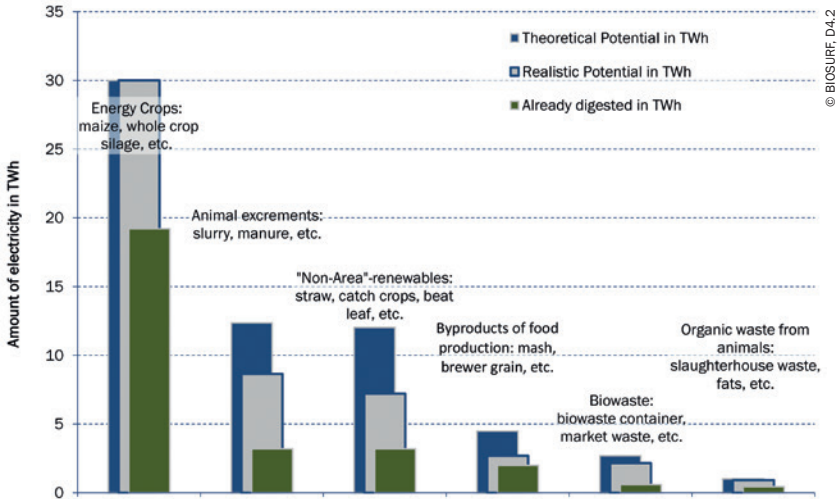

Fig. 8 Current usage and future potential of various substrates for biogas and biomethane production in terrawatt/hour (TWh) per year for Germany

of energy or otherwise as a material source. The possible utilisation of the remaining potential in this segment depends primarily on future policy-making. Animal excrements represent the second-highest potential. The potential in Germany is approximately 38 PJ/a (10 TWh/a).

CALCULATION OF GREENHOUSE GAS EMISSIONS FROM THE PRODUCTION AND USE OF BIOMETHANE

As well as the sustainability of the substrates used, verification of actual savings on greenhouse gas emissions is a further key prerequisite for the production of sustainable biomethane. For producers and users of biomethane, the need to calculate individual greenhouse gas emission levels has become increasingly important in light of the subsidy policies implemented in Germany and the EU. The bases of assessments in most cases are the methodology rules set out in the EU Renewable Energy Directive (EU RED; 2015/1513/EC). However, greenhouse gas emission assessment based on this method brings up a number of questions and challenges with regard to biomethane, some of which remain to be answered. They relate, for example, to the oligotrophic by-product fermentation residue and to the handling of emission reductions from upstream processes (such as the anaerobic digestion of liquid manure).

BIOSURF supports market actors in compiling individual greenhouse gas emission balances by providing argumentation aids and a wide range of tools relating to methodological questions in the calculation of greenhouse gas emissions (see D5.1). BIOSURF has also comprehensively collated the available literature data on emissions reduction in the anaerobic digestion of agricultural residues and waste products as the basis for future greenhouse gas emission assessments (see D5.2). Based on the preliminary methodological work and the data base presented, in the next step, greenhouse gas emission assessments for biomethane production on a broad range of substrates were drawn up (see D5.3). These calculations can be used, for example, to derive methods of optimising the reduction of greenhouse gas emissions in future.

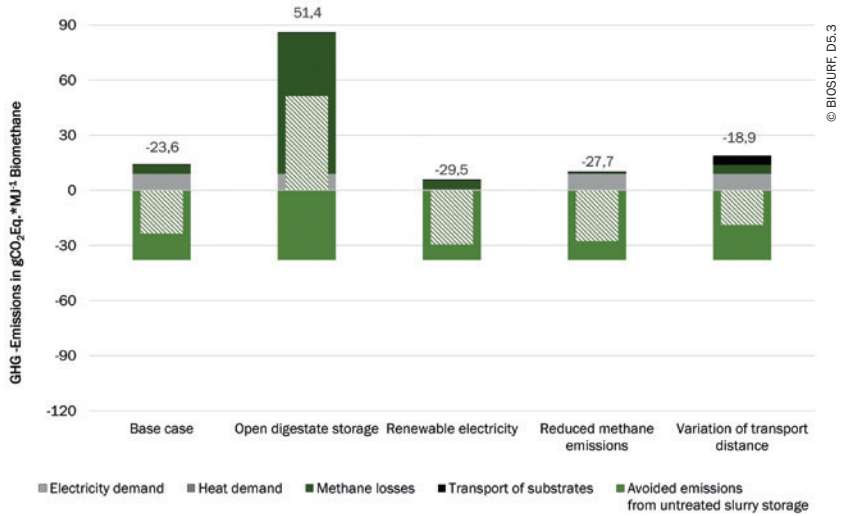

Fig. 9 Example parameter variation plotting the influence of individual parameters on the overall greenhouse gas emission balance

PROSPECTS

The BIOSURF project is in its final year. Up until the end of the year, the project partners will be working primarily on the infrastructure for a pan-European biomethane register. This is intended to further aid European biomethane trading, and in particular, eliminate existing technical obstacles. In addition to devising technical solutions for enhanced biomethane trading, as part of the BIOSURF project the DBFZ will mainly investigate the possibilities for linking greenhouse gas emission assessments to the European emissions certificate trading system within the framework of existing sustainability certification procedures. The final results of the BIOSURF project will be presented at a closing conference.

Additional information:
www.biosurf.eu/en_GB/
www.biosurf.eu/en_GB/downloads-and-deliverables/deliverables/

BACKGROUND: SYSTEMIC CONTRIBUTION OF BIOMASS

This area of research focus will contribute to the creation of sustainable bioenergy strategies at the national and international level. To that end, it will identify regional and global biomass potential and investigate and assess the wide-ranging options offered by different biomass recovery concepts. The primary aim is to answer methodological and technical system-related questions on the efficiency and sustainability of biomass use from economic, ecological and technical viewpoints, incorporating both the land resources used as well as treatment and conversion technologies specific to the energy source. The combination of these topic areas provides the basis for deriving strategies and recommendations for action for decision-makers in the political and business spheres.

Additonal information:
www.dbfz.de/en/focus-areas/systemic-contribution-of-biomass

Key reference projects and publications

Project: AG Biomassereststoffmonitoring, Bundesministerium für Ernährung und Landwirtschaft/ Fachagentur Nachwachsende Rohstoffe e. V., 01.07.2016–30.06.2018 (FKZ: 22019215)

Project: BEPASO – Bioökonomie 2050: Potenziale, Zielkonflikte, Lösungsstrategien, Bundesministerium für Bildung und Forschung/ Projektträger Jülich, 01.12.2016–30.11.2019 (FKZ: 031B0232B)

Project: Bioplan W – Systemlösungen Bioenergie im Wärmesektor im Kontext zukünftiger Entwicklungen, Bundesministerium für Wirtschaft und Energie/ Projektträger Jülich, 01.08.2016–31.03.2019 (FKZ: 03KB113A)

Project: ProgBegII – Programmbegleitung des BMWi-Förderprogramms "Energetische Biomassenutzung" – Ausbau des Wissenstransfers, Bundesministerium für Wirtschaft und Energie/ Projektträger Jülich, 01.07.2016–31.12.2019 (FKZ: 03KB001B)

Publication: Horschig, T.; Adams, P. W.; Röder, M.; Thornley, P.; Thrän, D. (2016). "Reasonable potential for GHG savings by anaerobic biomethane in Germany and UK derived from economic and ecological analyses". Applied Energy (ISSN: 0306-2619), H. 184. S. 840–852. DOI: 10.1016/j.apenergy.2016.07.098

Publication: Lauer, M.; Dotzauer, M.; Hennig, C.; Lehmann, M.; Nebel, E.; Postel, J.; Szarka, N.; Thrän, D. (2016). "Flexible power generation scenarios for biogas plants operated in Germany: impacts on economic viability and GHG emissions". International Journal of EnergyResearch (ISSN: 0363-907X). DOI: 10.1002/er.3592.

Publication: O'Keeffe, S.; Majer, S.; Bezama, A.; Thrän, D. (2016). "When considering no man is an island: assessing bioenergy systems in a regional and LCA context: a review". The International Journal of Life Cycle Assessment (ISSN: 0948-3349), Vol. 21, H. 6. S. 885–902. DOI: 10.1007/s11367-016-1057-1

Publication: Szarka, N.; Eichhorn, M.; Kittler, R.; Bezama, A.; Thrän, D. (2017). "Interpreting long-term energy scenarios and the role of bioenergy in Germany". Renewable and Sustainable Energy Reviews (ISSN: 1364-0321), H. 68, Part 2. S. 1222–1233. DOI: 10.1016/j.rser.2016.02.016.

Publication: Thrän, D.; Witt, J.; Schaubach, K.; Kiel, J. H. A.; Carbo, M.; Maier, J.; Ndibe, C.; Koppejan, J.; Alakangas, E.; Majer, S.; Schipfer, F. (2016). "Moving torrefaction towards market introduction: Technical improvements and economic-environmental assessment along the overall torrefaction supply chain through the SECTOR project". In: Overend, R.; Prins, W. (Hrsg.) Biomass & Bioenergy special issue of the 23rd European Biomass Conference and Exhibition held in Vienna, June 2015. Biomass and Bioenergy (ISSN: 0961-9534). H. 89. S. 184–200. DOI: 10.1016/j.biombioe.2016.03.004.

Project summary

Duration:	1 January 2015–31 December 2017
Project partners:	AGCS – Gas Clearing and Settlement Ag (AGCS); ARGE Kompost und Biogas Österreich Verein (AKB); Association Technique Energie Environnement (ATEE), Club Biogaz; Cib-Consorzio Italiano Biogas E Gassificazione (CIB); Deutsches Biomasseforschungszentrum (DBFZ); European Biogas Association (EBA); Fachagentur Nachwachsende Rohstoffe e. V. (FNR); Fachverband Biogas e. V. (GBA); Istituto di Studi per L'Integrazione dei Sistemi Scrl (ISINNOVA); Magyar Biogaz Egyesulet (HBA); Renewable Energy Association Lbg (REA)
Scientific contact:	Stefan Majer
Project number:	Grant Agreement No. 646533
Funding body:	EU/Horizon 2020 programme

Head of the research focus area

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3.2 ANAEROBIC PROCESSES

"The working hypothesis in the research project 'RegioBalance' is that the utilisation of a pro-active feed-in management (paFeedMan) for flexible biogas plants in power distribution grids a) reduces the grid load of power distribution grids and therefore, b) can generate savings in comparison to conventional measures for grid expansion in the course of grid development."

Tino Barchmann, Project Coordinator

FLEXIBLE ANAEROBIC DIGESTION (AD) PLANTS AS REGIONAL BALANCING OPTION IN POWER DISTRIBUTION GRIDS

The project focuses on technologies for flexible AD plants contributing to demand-oriented power generation within the context of direct marketing (Renewable Energy Sources Act: EEG 2012, EEG 2014) on the assumption that their operating mode is grid-supporting. This flexible operation is simulated for typical AD plants and their effect on five exemplary substation districts (SDs) on the level of distribution grids is evaluated both technically and economically.
Within the research project "RegioBalance" the DBFZ examined if controllable and flexibly operated AD plants can contribute, to avoid or lower the demand for medium voltage grid expansion. It was determined if a smart integration of these flexibility options is economically beneficial in comparison to conventional grid expansion. For this purpose, five medium voltage SDs (20 kV) were investigated. Regarding those five power distribution grids different scenarios were calculated to show how the usage of flexible AD plants has to be evaluated grid-related and to demonstrate how the resulting costs have to be interpreted economically compared to potential savings for grid expansion until 2025. Therefore, an evaluation approach was developed to compare the flexibility option "flexible bioenergy with paFeedMan" (pro-active feed-in management) with an exclusive power grid expansion.

METHODOLOGY/MEASURES

The grid-related effects of the illustrated grid-beneficial operation were examined and economically quantified in the course of the project. In the working hypothesis it was assumed that in comparison to conventional operation, the additional costs of a "smart" paFeedMan for ADs can be overcompensated by the savings of grid operators. Thus, it can be of economic advantage to prefer this option to grid expansion or to include it as a permanent addition to the grid expansion. The performance of an AD plant for an operation that is beneficial to the grid, i. e. the delivery of a defined flexibility performance, was analysed on the basis of a grid-related calculation of scenarios for SDs in the medium voltage grid. Therefore, a scenario framework for the years 2020 and 2025 was developed to draw appropriate comparisons.
For all calculations, SDs of the medium voltage level in North and East Germany were chosen as objects of study. Calculations of several scenarios for 2020 and 2025 revealed how different the effects of a flexible generation are. In the following, assumptions were made regarding possible degrees of flexibility of the AD plants installed in these substation districts. The scenarios focus on two different evaluations, both for the same years. On the one hand, flexible AD plants with an EPEX-optimised feed-in were investigated. On the other hand, AD plants that consider grid restrictions regarding their power feed-in in addition to the electricity price orientation were evaluated. For both evaluations, a significant influence factor on grid load is that plants that are solely electricity price-oriented possibly feed-in power into the grid at times of high wind and solar power generation. Consequently, they imply a high simultaneity factor for the installed generation power. These periods of high simultaneous feed-in are the cause for high grid loads and therefore for the need of additional gird expansion.

The project shows how the plant's diverse operation modes affect the relevant grid parameters. Moreover, the need for expansion was ascertained by the calculated grid parameters. This was determined both for the scenarios with and without grid restrictions for an electricity price-oriented operation. The comparative analysis reveals the effects of a purposeful and grid-protecting use of flexibility as well as possible cost savings on the level of power grids. Altogether, five scenarios were arranged (basis scenario 2015, two scenarios for 2020 and two scenarios for 2025). Furthermore, by using an economic evaluation approach that was developed in the project, it was investigated if the use of flexibility options and their consideration in grid planning can be of advantage in comparison to grid expansion as seen from the perspective of the power system. Since the entire sector of power supply is characterised by strongly regulated markets, it was conclusively investigated which adjustment requirement would be necessary within the energy-economic legal framework to introduce a paFeedMan on the level of distribution grids.

RESULTS

1. Concept of paFeedMan

Hereby, controllable generating plants (in the project flexible AD plants) can contribute to the avoidance of limit value violations 24 hours in advance by taking grid restrictions into consideration in their schedule design of the CHPs. By this means, especially flexible producers can "compensate" load peaks caused by simultaneous high feed-in of wind and photovoltaics to reduce the maximal cumulated load of renewable energies. The examples of selected SDs show if and under which conditions the grid-beneficial usage of flexible AD plants can be an addition to the required grid expansion. The benefit of paFeedMan in grid planning is the calculation with a lower maximal feed-in power by which means the grid expansion can be reduced.

2. Grid-related effects

A time-variably grid-related limitation of flexible biogas feed-in (max. 25 % Pinst) in the context of paFeedMan in times of high feed-in by wind and solar energy plants

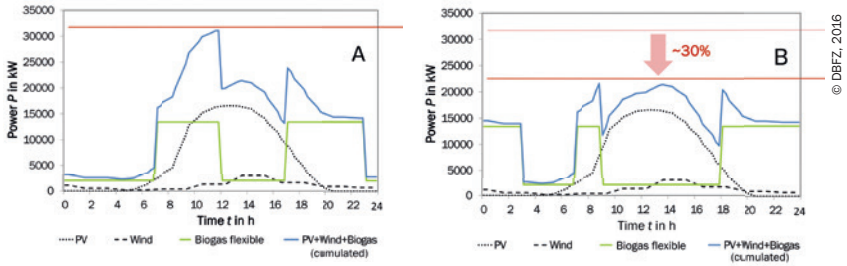

Fig. 10 Modelled load profile of a flexible AD plant operation (EPEX-optimised), in comparison: (left) without and (right) with consideration of grid restrictions

improves grid-technical parameters in selected SDs. Among others, reductions of transformer load, cable load and grid losses could be determined.

3. Economic evaluation approaches

A calculation of opportunity costs provides the basis. These costs as well as lost profits of an AD plant that is operated beneficially to the grid and the expenses for the implementation and realisation of paFeedMan are compared to the savings potential of future grid expansions. The results show that considerable savings at grid expansion can be generated and options for smart grid planning and grid management are economically reasonable. Therefore, they should be considered in the course of legal revisions in the future, e. g. in the Ordinance on Incentive Regulation (ARegV).

4. Analysis of energy-economic legal framework for flexibility provision on the level of power distribution grids

It should be noted that the regulatory framework does not allow a legal realisation for the implementation of paFeedMan at the level of distribution grids so far. A starting point for further development of the legal framework would be a debate about advantages and disadvantages for a provision of flexibility options on the level of distribution grids.

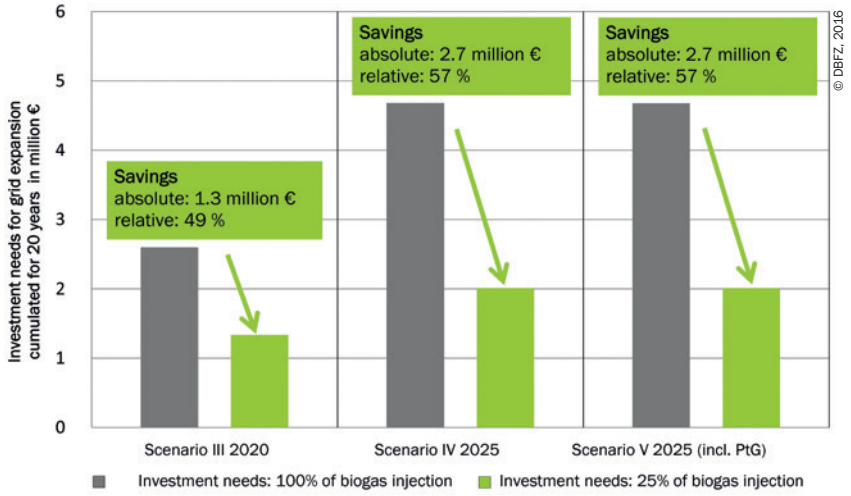

Fig. 11 Savings of grid expansion costs in example

OUTLOOK

The project reveals possible positive effects on the operation of power distribution grids on the medium voltage level by a smart use of flexible AD plants in the investigated SDs. The concept of paFeedMan shows how flexibility based on renewable energies can provide system services on the level of distribution grids at a mostly constant contribution to balance fluctuating residual loads.
Such an approach can only be realised reasonably by the regarding parties if the use of smart flexibility options is economically beneficial. The economic evaluation approach developed in this project compares the costs of paFeedMan including costs for implementation and realisation with possible cost savings from grid expansion. It is shown that an additional use of paFeedMan is economically reasonable in the considered grid areas. The approach of paFeedMan represents a significant intervention in the present organisation of responsibilities of grid operators. For this purpose, adjustments concerning the energy-economic legal framework would be essential. Here, the project results give viable recommendations for action.

BACKGROUND: ANAEROBIC PROCESSES

Processes using micro-organisms to convert biomass under anaerobic conditions form the basis of many biotechnologies for the production and supply of material and energy sources. The “Anaerobic Processes” research focus area primarily develops efficient and flexible methods of biogas production to meet the needs of future energy systems. Linkage to material recycling processes enhances the added value. To that end, the research focus area develops tools for process monitoring and control, concepts for flexible, low-emission plants and operating regimes, methods of assessing and optimising efficiency, as well as to maximise material turnover, particularly for difficult substrates.

Additional information:
www.dbfz.de/en/focus-areas/anaerobic-processes

Key reference projects and publications

Project: Biogas-Messprogramm III – Faktoren für einen effizienten Betrieb von Biogasanlagen – Teilvorhaben 1: Energiebilanzierung, Flexibilisierung, Ökonomie, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.12.2015–30.11.2018 (FKZ: 22403515)
Project: DEMETER – Demonstrating more efficient enzyme production to increase biogas yields, EU/Horizon2020, 01.08.2016–31.07.2019 (GA 720714)
Project: ELIRAS – Entwicklung eines Leitfadens zur Auswahl von standortspezifisch angepassten Rühr- und Substrataufschlussverfahren für Biogasanlagen, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.01.2015–31.12.2017 (FKZ: 03KB106A)
Project: MetHarmo – ERA-NET Bioenergy: Europäische Harmonisierung der Methoden zur Quantifizierung von Methanemissionen aus Biogasanlagen, ERANET/Fachagentur Nachwachsende Rohstoffe e. V., 01.03.2016–28.02.2018 (FKZ: 22028412)
Project: SubEval – Verbundvorhaben: Bewertung von Substraten hinsichtlich des Gasertrags – vom Labor zur großtechnischen Anlage; Teilvorhaben 1: Durchführung der Labor- und Praxisversuche, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.10.2015–30.09.2018 (FKZ: 22034614)
Publication: Hofmann, J.; Peltri, G.; Sträuber, H.; Müller, L.; Schumacher, B.; Müller, U.; Liebetrau, J. (2016). “Statistical Interpretation of Semi-Continuous Anaerobic Digestion Experiments on the Laboratory Scale”. Chemical Engineering

Project summary

Duration:	1 September 2013–31 January 2016
Project partners:	Deutsches Biomasseforschungszentrum, Energy2Market GmbH, E.DIS AG, 50Hertz Transmission GmbH, Uniper Technologies GmbH
Scientific contact:	Tino Barchmann
Project number:	03KB087
Funding body:	Federal Ministry for Economic Affairs and Energy (BMWi), Project Management Jülich (PTJ)

Supported by:

Federal Ministry for Economic Affairs and Energy

Projektträger Jülich Forschungszentrum Jülich

on the basis of a decision by the German Bundestag

& Technology (ISSN: 0930-7516), Vol. 39, H. 4. S. 643–651. DOI: 10.1002/ceat.201500473.
Publication: Kretzschmar, J.; Rosa, L. F.; Zosel, J.; Mertig, M.; Liebetrau, J.; Harnisch, F. (2016). "A Microbial Biosensor Platform for Inline Quantification of Acetate in Anaerobic Digestion: Potential and Challenges". Chemical Engineering & Technology (ISSN: 0930-7516), Vol. 39, H. 4. S. 637–642. DOI: 10.1002/ceat.201500406
Publication: Mauky, E.; Weinrich, S.; Nägele, H.-J.; Jacobi, H.-F.; Liebetrau, J.; Nelles, M. (2016). "Model Predictive Control for Demand-Driven Biogas Production in Full Scale". Chemical Engineering & Technology (ISSN:0930-7516), Vol. 39, H. 4. S. 652–664. DOI: 10.1002/ceat.201500412
Publication: Trommler, M.; Barchmann, T.; Dotzauer, M.; Cieleit, A. (2017). "Can Biogas Plants Contribute to Lower the Demand for Power Grid Expansion?". Chemical Engineering & Technology, Vol. 40, H. 2. S. 359–366. DOI: 10.1002/ceat.201600230.
Publication: Trommler, M.; Barchmann, T.; Dotzauer, M. (2016). Flexibilisation of biogas production: Impulses from EEG-legislation. Vortrag gehalten: Conférence biogaz sur la vente directe et le financement en France et en Allemagne, Paris (France), 03.03.2016.

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3.3 PROCESSES FOR CHEMICAL BIOENERGY CARRIERS AND FUELS

"In the 'KomBiChem^{Pro}' demonstration project, results from the various application-oriented developments of the alliance partners on the use of lignocellulose as a material source are being collated and demonstrated in integrated biorefinery concepts. Economically viable options based on this may be the production of sugars and/or fibres, as well as basic and fine chemicals."

Arne Gröngröft, Project Manager

KOMBICHEM^{PRO} DEMONSTRATION PROJECT– FINE AND PLATFORM CHEMICALS FROM WOOD BASED ON COMBINED CHEMICAL/ BIOLOGICAL PROCESSES – SUBPROJECT B

The use of organic residues and waste products, especially lignocellulose rich materials, has been advanced in recent years by various research initiatives under the auspices of the German Federal Government aimed at establishing a bioeconomy. A major focus is the development of efficient, integrated process chains – so-called biorefineries. They offer an integrated methods of recycling through various processes in order to utilise all lignocellulose components as far as possible, and to compete with the petrochemical industry.
The KomBiChem^{Pro} demonstration project is dedicated to the use of residual wood as a material source, combining new methods based on research in integrated biorefinery concepts. Whereas previous considerations related mainly to the conversion of C6 sugars into downstream products, or of lignin into bio-based aromat-

ics, the hemicellulose fraction, accounting for 20–40 % of lignocellulose, is now also being investigated. Yet no process paths have been established which would permit high-grade material usage and commercial exploitation of this component. That is reason enough to work on environmentally friendly conversion processes and purification methods for the production of organic acids and furans from a mixture of C5-C6 sugars originating from hemicellulose. In terms of the recovery of cellulose from the Organosolv process, the existing research focus aimed at recovering glucose as a fermentation base material is now also accompanied by attempts to recover fibres and pulp. The hydrothermal treatment of Organosolv lignin for the production of phenols is also being investigated.
The starting point for the use of organic residues and waste products as material sources is the fractionation of the lignocellulosic input materials into the components cellulose, hemicellulose and lignin by means of pulping. One process which has already been implemented and investigated on a pilot scale at the Fraunhofer Centre for Chemical-Biotechnological Processes (CBP) is the Organosolv process. In this, the lignocellulose is decomposed and fractioned using an ethanol/water mixture. While the processing of cellulose into sugars and fibres is already well advanced, there is still a major need for further development with regard to the hemicellulose and lignin fractions.

SUGAR FROM HEMICELLULOSE

In the KomBiChem^{Pro} project, the DBFZ is investigating the possibility of hydrothermal conversion of the hemicellulose fraction. The results will subsequently be piloted at the Fraunhofer CBP. Hydrothermal processes are outstandingly well suited for the conversion of such aqueous fractions, since water is required as reaction medium for those processes. Beside cellulose and lignin, hemicellulose is one of the most frequently occurring biopolymers of lignocellulose biomass, and is mainly composed from interlinked C5 sugar units (pentoses) and in part from C6 sugars (hexoses). The hydrothermal processes developed at the DBFZ are capable, firstly, to split those C5 and C6 sugar chains and converting them into furfural and 5-hydroxymethylfurfural (5-HMF). On the other hand, environmental polluting waste streams are prevented by avoiding the use of mineral acids such

Fig. 12 **High-grade chemicals can only be recovered from hydrothermal processes by separating the product solution into its individual components**

as hydrochloric and sulphuric acid. Furfural and 5-HMF are generally classed as base chemicals for a wide range of high-value bio-based chemicals such as synthetic resins or polyethylene furanoate (PEF) as a substitute for polyethylene terephthalate (PET). The aim of the work at the DBFZ is to develop a hydrothermal process for the conversion of hemicellulose solution from the Organosolv process into high-value starting materials such as monomeric sugars (glucose/xylose), furfural and 5-HMF with high product yields, high levels of selectivity, low wastage, and low auxiliary material consumption. To that end, the DBFZ is using a tubular reactor to identify optimal reaction conditions in terms of yields of sugar monomers, furfural or 5-HMF.

SEPARATION PROCESSES AT THE DBFZ

Alongside hydrothermal conversion of the hemicellulose solution and its further processing, separation of the biomass components and product solutions is a further key element of KomBiChem^{Pro} (see figure 12). The DBFZ is particularly investigating the use of membrane filtration and preparative chromatography for the purpose. Membrane filtration can be used to separate the various material groups such as sugars, organic acids, furans and phenols based on their particle sizes. This delivers high potential for energy conservation compared to conventional separation methods. However, at the same time, fouling of the membrane and improved efficiency needs to be achieved. The DBFZ is using a test rig for membrane screening, enabling different membrane filtration grades from micro-filtration to reverse osmosis (see figure 13).

In order to obtain high-value substances of especially high purity, preparative chromatography processes are also being developed. Chromatography is a separation method which purifies mixtures based on the differing distribution of the individual components between a stationary and a mobile phase. As opposed to analytical high-performance liquid chromatography (HPLC), which analyses and measures sample contents, preparative HPLC is focused on recovering pure substances. The aim of preparative HPLC is to isolate maximum amounts in the desired purity in a short space of time. The requirements are maximum loading, minimal solvent consumption and optimal fractioning (no peak overlaying) with low input of eluent and process energy. A preparative batch-HPLC system devised specially for the project is used to separate out the specific product classes of organic acids, furan and phenol derivatives.

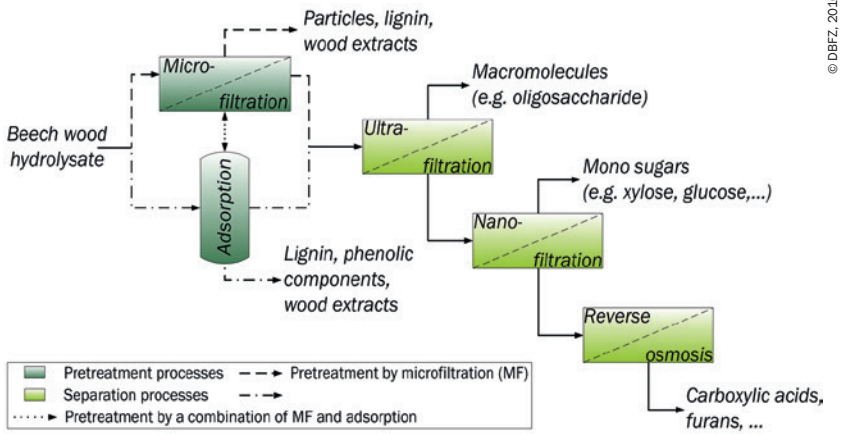

Fig. 13 Concept for the purification of beechwood hydrolysate by adsorption and membrane filtration

UPGRADING OF INTERIM PRODUCTS

The purified interim products, such as monomeric sugars, furfural or 5-HMF, are refined following the hydrothermal conversion step. The Fraunhofer CBP is investigating the necessary conversion methods. In doing so, biotechnological processes are used to obtain the products xylonic acid, malic acid or furan dicarboxylic acid. In those processes it is necessary to eliminate disturbing inhibitors prior to fermentation so that the micro-organisms can achieve the highest possible productivity. Other products such as furfuryl alcohol and tetrahydrofuran are produced from furfural by chemical conversion processes. The aim of the further conversion being advanced by the Fraunhofer CBP is to demonstrate the complete value chain from the raw material to the high-value chemical product. Testing facilities from laboratory to pilot plant scale are available for scaling purposes and to collect industrially relevant data.

PROCESS SIMULATION, COST ACCOUNTING AND SUSTAINABILITY

To ensure closely targeted development of the individual process steps, the entire value creation network must be viewed as a unified whole, so that the most favourable processes are identified. Decisions made during the concept design phase can influence as much as 80 % of the downstream cost, and thus impact

sustainability in subsequent operation. The DBFZ implemented assessment and dimensioning of material and energy flows by process simulation is a key tool for investigating suitable process chains. This enables technical analyses to be carried out, and upscaling effects identified, at a very early stage in process development. The results of the balance assessment are subsequently applied as the basis for cost accounting and sustainability assessments. The DBFZ thus incorporates economic and ecological criteria into its technology development right from the beginning.

PROSPECTS

The further steps in the KomBiChem^{Pro} project will focus on the experimental questions relating to hydrothermal conversion and the purification of the hemicellulose solutions. This will be done by means of extensive hydrothermal conversion trials with the continuously operating tubular reactor, as well as by experiments on the adsorption of impurities and filtration of valuable materials. The two topics will also be the subjects of doctoral theses. Towards the end of the project, the experimental results will be collated into a final balance and assessment.

BACKGROUND: PROCESSES FOR CHEMICAL BIOENERGY CARRIERS AND FUELS

This area of research focus is an important element of the overall process chain from the raw biomass material to biofuels and chemical bioenergy sources as products of biorefineries. In addition to process and concept development, it also comprises implementation on a laboratory and pilot plant scale, as well as assessment of technical systems. The primary aim is to contribute to flexible operating, high efficiency and sustainable conception of biorefineries by innovative technology. Thereby also the requirements within the context of the bioeconomy have to be fulfilled. To that end, chemical refinement focused on hydrothermal processes (HTP) will be advanced. The development of fractioning for solid-liquid and liquid-liquid separation plays a key role as a link between the individual areas of research focus (in particular in conjunction with anaerobic processes and HTP interim products). Another element is the development of synthesised gas processes to create high-value products, focused on biomethane in the form of bio-synthetic natural gas (bio-SNG). In the short term, an exemplary HTP-based biorefinery concept will be developed. To that end, the work within the research focus area will concentrate on (i) analysis of relevant individual processes and required system components; (ii) preliminary trials for selected individual processes (e.g. HTP, gasification, methanisation to form SNG) and (iii) preparation of an accompanying technical systems assessment (focus: material and energy balancing, cost and economic viability, environmental impact).

Additional information:
www.dbfz.de/en/focus-areas/processes-for-chemical-bioenergy-sources-and-fuels

Key reference projects and publications

Project: AUFWIND – Algenproduktion und Umwandlung in Flugzeugtreibstoffe: Wirtschaftlichkeit, Nachhaltigkeit, Demonstration; Teilvorhaben 3: Systemanalyse, Ökonomie und Ökologie – Technische und ökonomische Gesamtbewertung, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e.V., 01.06.2013–31.08.2016 (FKZ: 22408812)

Project: Diesel Kat Aging II – Verbundvorhaben: Schnelltest zur Alterungsnachstellung von Dieselabgaskatalysatoren im Betrieb mit Biokraftstoffen; Teilvorhaben 1, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e.V./Forschungsvereinigung Verbrennungskraftmaschinen (FVV) e.V., 01.10.2014–31.12.2017 (FKZ FNR: 22014514; FKZ FVV: 6011792)

Project: FEBio@H2O – Verbundvorhaben: Flüssige Energieträger aus einer integrierten hydrothermalen Umwandlung von Biomasse, Teilprojekt "Biomasseabbau und Gesamtprozess", Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.01.2013–31.10.2016 (FKZ: 03EK3508A)

Project: GRAIL – Glycerol Biorefinery Approach for the Production of High Quality Products of Industrial Value, EU-Projekt, 01.11.2013–31.10.2017 (GA 613667)

Project: HTCuPH – Spitzencluster BioEconomy: TG 4, Bioraffinerie zur integrierten hydrothermalen Produktion von Brennstoff sowie der Grundchemikalien Phenol und Furan aus Biomasse, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.11.2014–30.09.2017 (FKZ: 031A445A)

Publication: Müller-Langer, F.; Zech, K.; Rönsch, S.; Oehmichen, K.; Michaelis, J.; Funke, S.; Grasemann, E. (2016). Assessment of Selected Concepts for Hydrogen Production Based on Biomass. In: Stolten, D.; Emonts, Bernd (Hrsg.) Hydrogen Science and Engineering: Materials, Processes, Systems and Technology. Weinheim: Wiley. ISBN: 978-3-527-33238-0. S. 393–416.

Publication: Nitzsche, R.; Budzinski, M.; Gröngröft, A. (2016). "Techno-economic assessment of a wood-based biorefinery concept for the pro-

Project summary

Duration:	15 November 2015–14 May 2018
Project partners:	Deutsches Biomasseforschungszentrum, Fraunhofer Centre for Chemical-Biotechnological Processes (CBP)
Scientific contact:	Arne Gröngröft
Project number:	031B0083B
Funding body:	German Federal Ministry of Education and Research (BMBF), Project Management Jülich (PTJ)

duction of polymer-grade ethylene, organosolv lignin and fuel". Bioresource Technology (ISSN: 0960-8524), H. 200. S. 928–939. DOI: 10.1016/j.biortech.2015.11.008.

Publication: Rönsch, S.; Köchermann, J.; Schneider, J.; Matthischke, S. (2016). "Global Reaction Kinetics of CO and CO_2 Methanation for Dynamic Process Modeling". Chemical Engineering & Technology (ISSN: 0930-7516), Vol. 39, H. 2. S. 208–218. DOI: 10.1002/ceat.201500327.

Publication: Schneider, J.; Rothfuss, P.; Rönsch, S. (2016). "Dynamic simulation of a decentralized polygeneration plant providing SNG, steam and power". International Journal of Sustainable Engineering (ISSN: 1939-7038), Vol. 9, H. 5. S. 338–344. DOI: 10.1080/19397038.2016.1182598.

Publication: Zech, K.; Meisel, K.; Brosowski, A.; Toft, L. V.; Müller-Langer, F. (2016). "Environmental and economic assessment of the Inbicon lignocellulosic ethanol technology". Applied Energy (ISSN: 0306-2619), H. 171. S. 347–356. DOI: 10.1016/j.apenergy.2016.03.057.

Head of the research focus area

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3.4 SMARTBIOMASSHEAT

"The goal of the 'KombiOpt' project is to enhance the efficiency of existing biomass heaters. The optimisation is to be effected at the lowest possible cost, utilising the existing plant infrastructure. The targeted measures aim to substantially reduce fuel costs."

Daniel Büchner, Project Manager

KOMBIOPT – ENERGY MANAGEMENT SYSTEM FOR THE COMBINED USE OF RENEWABLE ENERGY

With some 12 million installed furnace systems (single-chamber furnaces and central heating boilers), wood burning is a major contributor to domestic heating provision and drinking water supply. Solid biomass contributed around 40 % of the total heat supplied to private homes from renewable energy sources in Germany in 2015. However, the increasing use of wood is also exacerbating emissions problems. Law-makers are attempting to counter this trend by increasingly tightening the limits for air-borne emissions through recurrent measurement tests based on the Federal Emmission Control Regulation (1. BImSchV). Alongside emissions from wood stoves, the focus of public interest is increasingly shifting to the efficiency of energy production [1,2]. Whereas the efficiency of wood stoves under test conditions has improved from around 55 % to over 93 % since the 1980s [3], the trend is not confirmed by real-world measurements. Recent surveys show that the efficiency of automatically loaded wood stoves in practice is in a range between 65 % and 85 % [4,5]. The efficiency of pellet boilers is very heavily de-

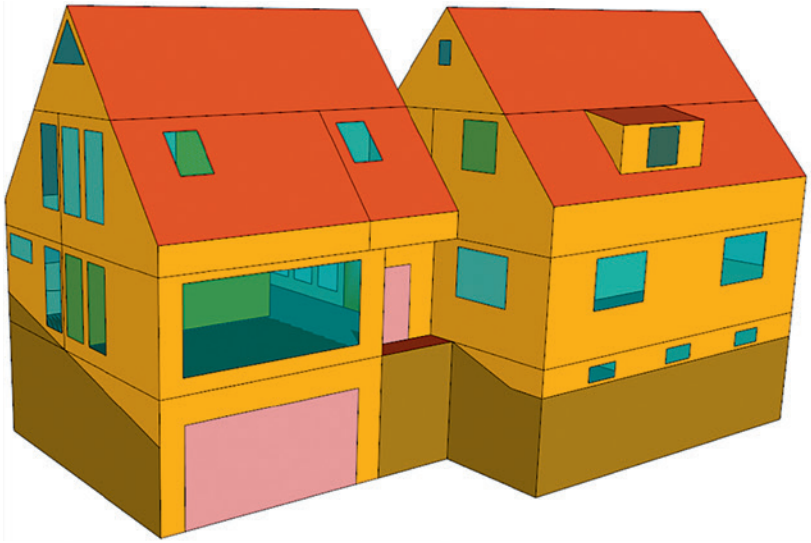

Fig. 14 3D model of the reference building (the building on the left is heated by an underfloor heating system; the one on the right by radiators)

pendent on the operating regime [6,7,4]. Low-load operation with very low output, rapidly alternating load cycles and pulsed operation with rapid start-stop cycling were identified as the main reasons in past years.

Consequently, high efficiency paired with low emissions is a key demand on state-of-the-art wood stoves. Against this background, the "KombiOpt" project is seeking to develop control strategies which will enable total final energy consumption – and thus the consumption-related costs of pellet/solar combination plants in detached and semi-detached homes – to be minimised. The higher-level, centralised building control will automatically make the necessary adjustments to individual components' operating parameters, so providing a universal basis for subsequent adaptation to different buildings and system configurations. Alongside predictive storage management, automated adaptation of pellet boiler operation is a core focus of the work. The safety functions of the pellet boiler and the actual combustion control will not be affected by the higher-level control system. The control system will enable plant operators to significantly improve the operating performance of existing heating installations without the need for major modification.

The control algorithm is being developed on the basis of a reference plant comprising a pellet boiler with a nominal output of 15 kW_{th} and a solar-thermal plant (10 m^2 flat plate collectors, elevated) in combination with a heat store with a total capacity of 1,000 l. The heat is supplied to the detached house with a built surface area of 240 m^2 by way of radiators and an underfloor heating system. Figure 14 shows a 3D model of the analysed reference building.

METHODOLOGY

At the start of the project the reference plant was updated to the technical state of the art. It underwent a comprehensive service, the automatic firing system was replaced in full by a new model, and the latest software was installed. Parts of the burner plate were also replaced. The installed boiler has thus been updated in line with the latest models, and is identical to the pellet boiler in use on the test rig. As a further measure, the existing measuring systems were upgraded. A total of five heat meters were installed, in all balance circuits. Temperature and humidity sensors were additionally installed in two rooms. The data was continuously recorded at 10 second intervals. The processes in the reference plant were analysed at the start of the project as a basis for deriving optimisation measures. The analysis covered the processes within the individual components, the mutual influencing of the respective components, as well as external influences. Based on the results obtained, a dynamic building and plant simulation was created in TRNSYS in order to investigate the interactions of internal and external processes and to optimise the heating system. Transient simulation of the complete system helps in testing of different control methods and in determining the theoretically attainable optimum. The results of the theoretical optimisation form the basis for laboratory experimentation. The experiments in turn serve to verify functionality in a practically oriented operating environment, and to determine the achievable effects under laboratory conditions. The final stage is demonstration of the control concept in the reference plant.

OPTIMISATION METHODS

For transient simulation in TRNSYS, various models (types) were developed. To determine the return temperatures of the heating circuits with type 278 a component was programmed which is capable of simulating the building's heat consumption in two modes. Mode 1 calculates the return temperatures based on the respective input temperatures, flow rates and heat outputs, while Mode 2 measures the current heat load for the input temperatures, flow rates and return temperatures within the analysed time step. Type 279 is a model of the heating controller installed in the reference building. Its primary roles are to monitor the relevant temperatures of the heating system and transmit the signal to turn the pellet boiler on and off. It also includes a function to calculate the target temperatures of the heating circuits, a weekly anti-legionella program, a boiler minimum off and on time monitor, as well as a user heating control timer. Type 212 is an upgraded development of type 210 – a model to simulate a pellet boiler. To precisely simulate the reference installation's boiler, the original model was upgraded [8,9]. The key upgrades were expansion and concretisation of the start phases and implementation of a fire-bed model. In type 212 a total of seven pellet boiler operating states are defined. Each of the states is assigned different air and fuel flow rates, as well as in part dynamically varying retention times of the fuel in the fire-bed. An automatic output and pump regulator was also implemented. With the adapted model, the operating performance of the reference boiler can be mapped in great detail. The model still currently has some weaknesses in terms of the different start-up types that occur in practice. Further upgrading is necessary in this respect.

The goal of the optimisation is to avoid operating states which impact negatively on boiler efficiency and emissions. Tests to date have identified the duration of modulation and the timing of boiler running as the key influencing factors. The preliminary trials and measurement data indicate a statistically significant influence on boiler efficiency of the time for which the boiler runs in regulation mode (the modulation phase). Extending the running times reduces boiler stops and starts. The time for which boiler running can be extended is constrained by the available storage capacity and the lower modulation limit (mostly 30 % of the nominal output) of the pellet boiler. Accordingly, running times can only be extended in conjunction with a reduction in boiler workload. The assessment must also consider potential negative effects resulting from the increasing part-load running.

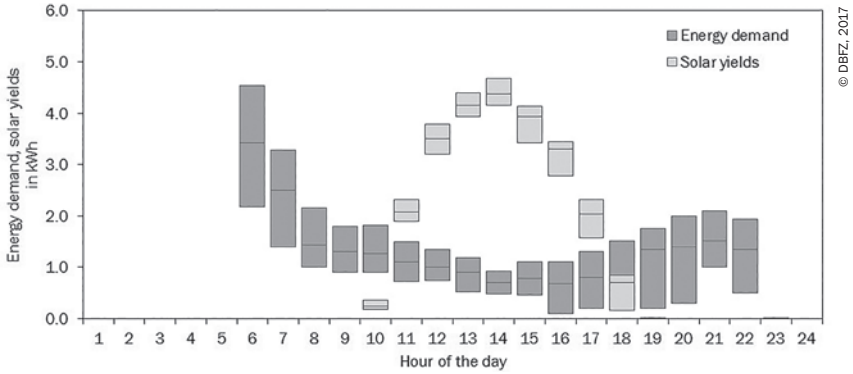

Fig. 15 **Boxplot of energy demand and solar yield for a week-day in a transitional period (the boxes mark the positions of the middle 50 % of the measurement data assigned to the day-type)**

Owing to the lack of information as to the short-term expected energy demand, boiler start-ups regularly occur in practice either shortly before the end of the daily heating periods or shortly before the energy demand falls. The former case results in an unnecessarily high temperature level in the storage tank, which primarily leads to loss of stored energy overnight. The lack of predictive capability means the control system is also not able to predict the actual energy demand and adapt the operating characteristics accordingly. That mainly results in the boiler running at well above the actually required output.

A modified variant of VDI 4655 is applied to predict energy demand. The building's energy demand is assessed on the basis of eight different typical days. These are broken down into summer-time, transitional period, winter-time and frosty days, as well as working days and weekends. The data from the reference plant is applied to assign a day to a day-type. The expected weather conditions (ambient temperature, global radiation, wind direction and speed, clouds) for the location are provided once a day by the German Meteorological Office. The energy produced by

the solar plant for the same period is additionally predicted. This is broken down by summer-time, transitional period and winter-time days, as well as days with high, low or uncertain solar yields. Additionally considering predictive quality enables better adaptation of the yield corridor. Figure 15 shows the predicted energy demand and solar yield characteristics based on the example of a transitional period day. Based on these assignments, the timing of boiler start-ups and the expected running times, with the associated target boiler water temperature, are determined. The boiler is always run at a higher output, or turned on as necessary, if the temperature in the tank falls below a minimum.

PROSPECTS

In Spring 2017, project partner EIFER will install and test the heating controller with standard functionality in the reference plant. In parallel, the system controller will be upgraded and trialled with the optimisation functions under test rig conditions at the DBFZ. On successful completion of the tests, this controller will likewise be installed and tested in the reference plant. However, on-site testing is constrained by the fact that, owing to the plant structure, the control system has to be substantially modified to perform the integration and security of supplied must be assured. Consequently, only a basic controller concept will be tested in the reference plant. In the same period, it is additionally planned to upgrade the boiler model by implementing different start-up types (cold start, warm start, false start).

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[9] T. Persson, F. Fiedler, S. Nordlander, C. Bales, J. Paavilainen, Validation of a dynamic model for wood pellet boilers and stoves, Applied Energy. 86 (2009) 645–656. doi:10.1016/j.apenergy.2008.07.004.

BACKROUND: SMARTBIOMASSHEAT

This research focus area concentrates on small-scale, renewable heat production in single units and small combinations up to village or town-neighbourhood scale using intelligent heat technologies interlinking other renewable energy sources and based on biomasses primarily originating from residues, by-products and

wastes. The primary aim is to make optimal technological and economic use of all renewable heat resources based on flexible, demand-adapted deployment of heat technologies based on biomass. This involves mapping the entire chain from grafting of the biomass fuels through new conversion plants to integration into the heat and power grid of the biomass heaters (executed in future also as combined heat and power plants), analysing, simulating and optimising them individually and collectively. It will also entail the necessary technical component development and linking control research and development through flexible operation (including micro- and small-scale CHP) to achieve efficient, environmentally friendly, economical, safe, demand-adapted, flexible and sustainable (smart) operation.

Additional information:
www.smartbiomassheat.com

Key reference projects and publications

Project: AUTOBUS Plug-and-Run-Prinzip – Automatische Integration von Wärme-und Stromerzeugern sowie Verbrauchern in eine Objektversorgung nach dem Plug-and-Run-Prinzip, Sächsische Aufbaubank, 01.08.2016–31.07.2019 (FKZ: 100250636)

Project: MPell – Kleinpellets – Grundlegende Voruntersuchungen zum Einsatz kleiner Holzpellets in Pelletöfen zur Emissionsminderung, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e.V., 01.08.2016–31.07.2017 (FKZ: 22404615)

Project: TorrAn – Torrefizierung und Analyse von EFB- und Reisspelzenpellets, timura Holzmanufaktur GmbH, 26.09.2016–31.10.2016 (FKZ: 3110027)

Project: WKK – Mikro-Wärme-Kraft-Kopplung, Sächsische Aufbaubank, 01.08.2016–31.07.2019 (FKZ: 100253153)

Publication: Safer, K.; Tabet, F.; Safer, M. (2016). "A numerical investigation of structure and NO emissions of turbulent syngas diffusion flame in counter-flow configuration". International Journal of Hydrogen Energy (ISSN: 0360-3199), Vol. 41, H. 4. S. 3208–3221. DOI: 10.1016/j.ijhydene.2015.12.154.

Publication: Bdour, M.; Al-Addous, M.; Nelles, M.; Ortwein, A. (2016). "Determination of Optimized Parameters for the Flexible Operation of a Biomass-Fueled, Microscale Externally Fired Gas Turbine (EFGT)". Energies (ISSN: 1996-1073), Vol. 9, H. 10. DOI: 10.3390/en9100856.

Publication: Khalsa, J. H. A.; Döhling, F.; Berger, F. (2016). "Foliage and Grass as Fuel Pellets: Small Scale Combustion of Washed and Mechanically Leached Biomass". Energies (ISSN: 1996-1073), Vol. 9, H. 5. DOI: 10.3390/en9050361.

Publication: Ortwein, A. (2016). "Combined Heat and Power Systems for the Provision of Sustainable Energy from Biomass in Buildings". In: Filipowicz, M.; Dudek, M.; Olkuski, T.; Styszko, K. (Hrsg.) 1st International Conference on the Sustainable Energy and Environment Development (SEED 2016): Kraków, Poland, May 17–19, 2016. E3S Web of Conferences (ISSN: 2267-1242). H. 10. DOI: 10.1051/e3sconf/20161000134.

Publication: Thrän, D.; Lenz, V.; Liebetrau, J.; Müller-Langer, F.; Tafarte, P. (2016). Smart bioenergy: providing flexible bioenergy for energy systems with high shares of renewables. In: Faaij, A.; Baxter, D.; Grassi, A.; Helm, P. (Hrsg.) Papers of the 24th European Biomass Conference and Exhibition: Setting the course for a biobased economy. Extracted from the Proceedings of the International Conference held in Amsterdam, The Netherlands, 6–9 June 2016. Florence (Italien): ETA-Florence Renewable Energies. ISBN: 978-88-89407-165. S. 1606–1611. DOI: 10.5071/24thEUBCE2016-5CP.2.1.

Project summary

Duration:	1 February 2015–31 July 2017
Project partner:	Deutsches Biomasseforschungszentrum (DBFZ), EIFER Europäisches Institut für Energieforschung EDF-KIT EWIV
Scientific contact:	Daniel Büchner
Project number:	22403113
Funding body:	German Federal Ministry of Food and Agriculture (BMEL), Fachagentur Nachwachsende Rohstoffe e. V. (FNR)

With support from

Federal Ministry of Food and Agriculture

FNR Fachagentur Nachwachsende Rohstoffe e.V.

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3.5
CATALYTIC EMISSION CONTROL

"The goals of the 'MWRWKat' project are to research and develop a catalytic waste gas cleaning process for small-scale biomass furnaces, and to technically implement the innovative concept in a prototype, in which the catalyst is activated thermally by means of dielectric heating by microwaves or radio waves"

Dr. Ingo Hartmann, Project Manager

MWRWKAT – DEVELOPMENT OF AN INNOVATIVE WASTE GAS POST TREATMENT SYSTEM FOR SMALL-SCALE BIOMASS FURNACES UTILISING INNOVATIVE CATALYSTS AND DIELECTRIC HEATING

The goal of the project is to research dielectrically aided post-combustion on small-scale biomass furnaces in order to reduce emissions of not fully oxidised gaseous combustion products (in particular CO and VOCs). This is to be done primarily by utilising direct energy input to provide rapid heat-up of the catalyst in the critical ignition and burn-off phases. The laboratory reactor system was equipped with radio wave and microwave generators, in order to systematically investigate dielectric heat-up in support of oxidation reactions on different catalysts by means of differing high-frequency fields. The necessary measuring and analytical systems were also selected and implemented. Based on the laboratory tests conducted, initial plans were carried out for implementation of the laboratory system in the prototype. As part of this, the required measuring system needed to be made more compact than that of the laboratory reactor, and be integrated

into an intelligent automatic control unit. A key factor in this is the temperature measuring system, which as far as possible needs to be run during dielectric heat-up. To that end, a regime using an IR camera was developed, for example, as shown schematically in Figure 16.

SYNTHESIS OF INNOVATIVE CATALYSTS

By way of example, various catalysts selected are provided by the Company "Emission Partner", and will be adapted to the process and optimised further in the course of the project as new findings emerge. The catalysts will be synthesised by so-called reactive coating, based on solid state reactions. The used noble metal-free mixed-oxide catalysts were applied to the monoliths by airbrush technique developed within the project. Here, an emulsion is produced from a carrier liquid (such as water with a thickening agent) and an active powder, and sprayed onto the foam block using an airbrush gun (see Figure 17). As a result, the catalysts can be produced much more quickly, and also with more components, than would be possible by conventional synthesis (impregnation). Alongside the synthesis itself, work is also being carried out to optimise the geometry of the catalyst for commercial application. Regarding this, ease of handling and conservation of resources are the crucial factors. The flow through the catalyst based on the most favourable construction possible is being specified and improved by means of simulation and practical experience. The experience gathered will also be incorporated into the design of the prototype.

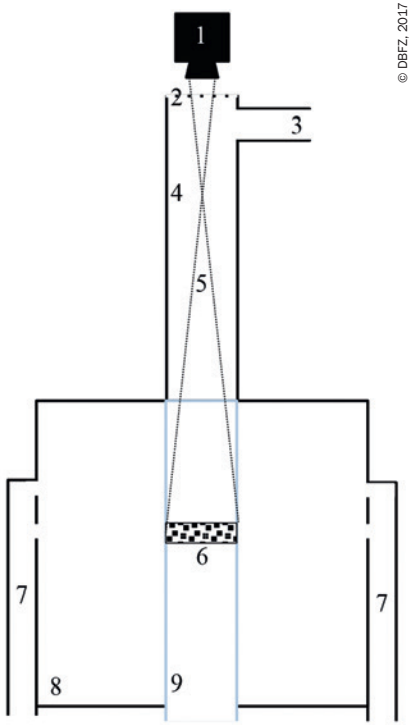

Fig. 16 Schematic of temperature measurement by IR camera*

*Where: 1) IR camera, 2) Screen gauze 3) Gas outlet 4) Optical transmission tube 5) Beam path 6) Catalyst (in radio wave application with RW electrodes) 7) Waveguide for microwave input 8) Reactor chamber 9) Glass tube.

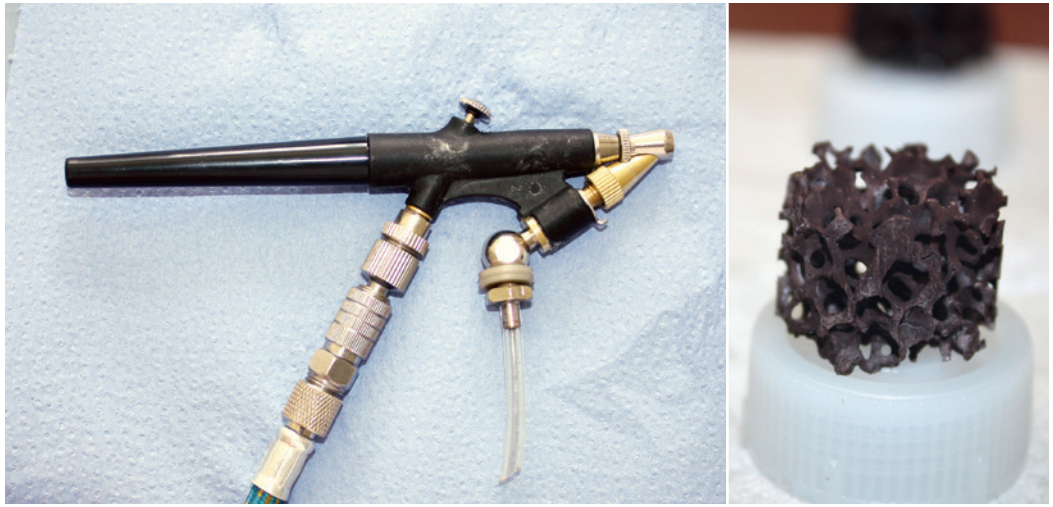

Fig. 17 Airbrush gun (left) used to coat foam ceramics (right)

MATERIAL CHARACTERISATION

In order to detect possible changes in properties directly – that is, not just by way of changes in reaction behaviour – and to conduct a suitability analysis of the catalysts on that basis, the materials are analysed by physical and chemical characterisation methods. The aim is to correlate the structural properties with the catalytic properties in order to identify potential for further optimisation.

REACTION CHARACTERISATION

The focus of the relevant studies is to identify the process-specific reaction behaviour of the catalysts aided by activity measurements on an ideal laboratory reactor. The changing activity properties of catalysts as a result of changed synthesis and ageing processes are being tested on the DBFZ's catalyst test bed. This laboratory reactor is very well suited to the characterisation of catalytic activity when using a model gas or a real waste gas under idealised reaction conditions. The laboratory catalyst test bed consists of a quartz glass reactor, a tube furnace, a model gas mixer and feed unit, a compressed air supply, and a gas analyser for the CO, O_2, NO and CH_x components (the last of those in the form of a VOC total signal). The catalytic activity of the samples is investigated based on oxidation of the model gases methane or propane, and the corresponding temperature/conversion curves are plotted in stationary mode. Based on this data, Arrhenius

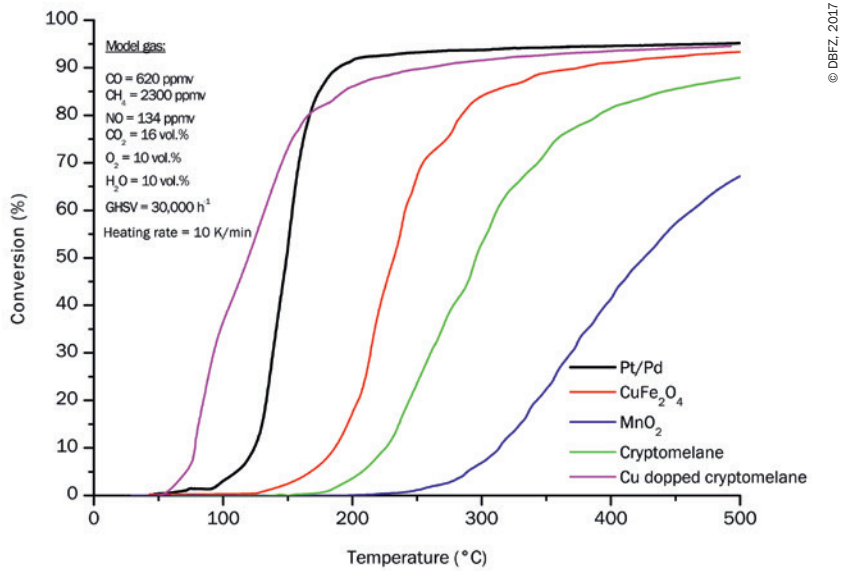

Fig. 18 Carbon monoxide conversion for various catalysts as a function of temperature

curves can be calculated which enable the activation energy and pre-exponential factor to be determined. Following scientific analysis, the activity and ageing parameters will be applied to the prototype's control routine in order to achieve the longest possible catalyst life.

SELECTIVE HEATING AND NON-THERMAL EFFECTS

The catalysts presented and being investigated are normally multi-phase systems. This normally predetermines differing dielectric properties in the system, and thus in principle the creation of temperature gradients in dielectric heat-up. The extent to which these might lead to stationary temperature gradients in view of the internal heat transfer processes remains to be clarified. In this context, a more detailed understanding of running processes represents a possible basis for the targeted improvement of such systems.

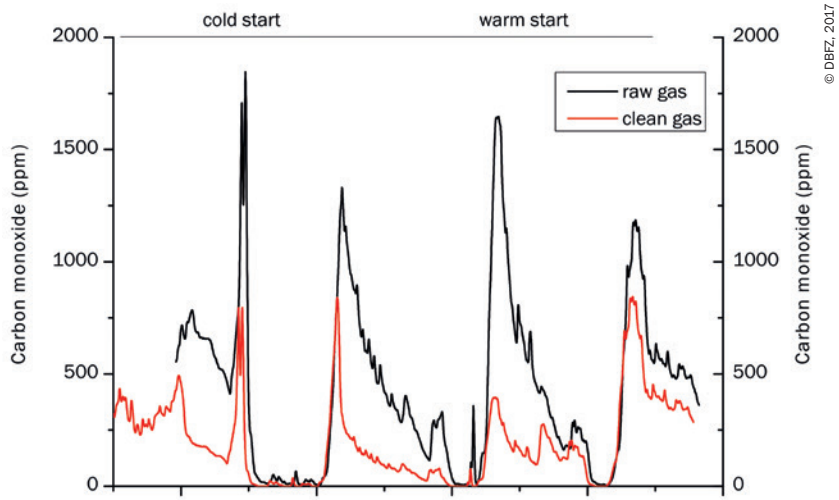

Fig. 19 Depiction of carbon monoxide degradation by a noble metal catalyst system activated by microwaves on a silicon carbide-contaminated aluminium oxide foam

INVESTIGATIONS IN THE STATIONARY REGIME

The achievable reduction in the pollutants CO, VOC, PAH* and soot will be quantified by means of targeted measurement series on both furnace types (stove and pellet boiler) and investigated with regard to practically relevant operating parameters. Applying the selected catalysts, the pollutant conversion rates subject to varied microwave and radio wave radiation and the attained temperature will be compared against each other. The results will be analysed taking into account the axial and radial temperature profiles in the catalyst bed. The efficiency of electromagnetic heating for the two frequency ranges applied will additionally be determined. To that end, energy balances must be calculated for the specific furnace designs and for the catalysts.

THERMAL AND HIGH FREQUENCY-SPECIFIC AGEING

To determine the specific ageing characteristics, comparative measurements will be conducted between microwave – and radio wave heating and conventional heating under the same heating conditions (primarily heat-up rates). For the purpose, the catalysts will be specifically aged with real waste gas in conventional heating as well as in microwave – and radio wave heating. Initially an ageing time of 50 operating hours (two weeks' trial running at 5 hours per working day) will be applied per catalyst sample and heating method.

INVESTIGATIONS IN CRITICAL NON-STATIONARY MODE

For the targeted oxidative decomposition of pollutants from domestic small-scale furnaces in start-up and shut down phases, as well as batch burn-off processes, the influence of MW/RW heating from the selected catalyst systems will be investigated. Supplementing this, the properties of the catalysts (conversion rate, CO_2 selectivity, stability) will be investigated on the existing catalyst test bed with model pollutants, taking into account possible structural changes.

INTEGRATION CONCEPT AND PROCESS DESCRIPTION

Based on the measurements and the comparison of catalyst properties, findings will be derived in the course of the project relating to the microwave and radio wave specific effects on pollutant reduction and catalyst ageing. This will then be used to devise a process concept for practical application. The findings will be analysed specifically for the selected catalysts. To specify the process and devise the integration concept, the advantages and disadvantages of the dielectric heating methods will be analysed, broken down by thermal and non-thermal effects. In addition to deriving the technical parameters, ensuring electromagnetic compatibility (EMC) under practical conditions will be a key factor in the project, and will be included in the integration concept. To that end, reference measurements are planned on the pilot plants at the DBFZ for both microwave and radio wave heating.

PROSPECTS

In 2017, the results of catalyst testing obtained to date on a laboratory scale will be transferred to the pilot plant. The best catalyst variants will be transferred to larger carrier systems and be subjected to waste gas. Additionally, in the first quarter of the year, sensors for a semi-automatic control system will be selected and procured if possible. Testing of long-term stability and non-stationary processes will also be more intensively placed at the focus of research work in 2017. To that end, selected catalyst systems will be subjected to waste gas and microwave energy for several days, in order to subsequently check their ageing in comparative measurements. Alternatively, radio wave testing will be continued under the leadership of the Helmholtz Centre for Environmental Research – UFZ. Simulations for flow calculation and determinisation of the size and shape of the electromagnetic field (MW and RW) will be continuously undertaken in the course of the project. This is intended to aid in the development of a prototype.

BACKGROUND: CATALYTIC EMISSION CONTROL

The primary aim of this focus area is to research catalytic emission control on incinerators for gaseous, liquid and solid bioenergy sources on solid-body catalysts. The focus lies on catalytic reduction of the incineration emissions of methane (CH_4), non-methane volatile organic compounds (NMVOCs), semi- and non-volatile hydrocarbons such as polycyclic aromatic hydrocarbons (PACs) and polychlorinated dibenzodioxins/polychlorinated dibenzofurans (PCDDs/PCDFs), soot particles (black carbon) and nitrogen oxides (NO_x). These pollutants can be substantially reduced by catalytic exhaust systems and integrated methods. The aim is to develop catalysts and processes which permit virtually zero-emission incineration of bioenergy sources in line with environmental requirements.

Additional information:
www.dbfz.de/en/focus-areas/catalytic-emssion-control

Key reference projects and publications

Project: Abscheider – Qualifizierung eines Staubabscheiders mit Katalysator an Biomassekleinfeuerungen, IHK zu Leipzig, Wirtschaft trifft Wissenschaft, 01.05.–30.09.2016

Project: Diesel Kat Aging II – Verbundvorhaben: Schnelltest zur Alterungsnachstellung von Dieselabgaskatalysatoren im Betrieb mit Biokraftstoffen; Teilvorhaben 1, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V./Forschungsvereinigung Verbrennungskraftmaschinen (FVV) e. V., 01.10.2014–31.12.2017 (FKZ FNR: 2201 4514; FKZ FVV: 6011792)

Project: SCR-Filter – Demonstration von Verfahren zur kombinierten Reduktion von Stickoxiden und Feinstaub aus Biomassefeuerungen, Bundesministerium für Wirtschaft und Energie/ Projektträger Jülich, 01.09.2014–31.12.2016 (FKZ: 03KB096A)

Project: HF-Technologie Abgas – Entwicklung einer innovativen Abgasnachbehandlungsanlage für Biomasse-Kleinfeuerungsanlagen unter Nutzung neuartiger Katalysatoren und dielektrischer Erwärmung, Bundesministerium für Wirtschaft und Energie/VDI/ VDE IT, 01.07.2015–31.12.2017 (FKZ: 16KN041428)

Publication: Bindig, R.; Butt, S.; Hartmann, I.; Dvoracek, D.; Einicke, W.-D.; Enke, D.; Specht, B.; Werner, F. (2016). Entwicklung, Untersuchung und Einsatz neuartiger katalytisch wirksamer Baugruppen zur Darstellung eines besonders emissionsarmen Kaminofens: nach dem Abschlussbericht (DBU-AZ 28412). (DBFZ-Report, 27). Leipzig: DBFZ. VII, 83 S. ISBN: 978-3-946629-05-4.

Publication: Butt, S. (2016). "Catalytic Oxidation of CO and CH_4 over Hexaaluminate based Catalysts". Proceedings of the Pakistan Academy of Sciences (ISSN: 2518-4261), Vol. 53, H. 4. S. 323–335.

Publication: Matthes, M.; Hartmann, I.; König, M. (2016). Emissionsarme Wärmebereitstellung aus Biomasse im kleinen Leistungsbereich (< 2 kWth). In: DBFZ-Jahrestagung 2016: Smart Bioenergy – Wie sieht die Zukunft der Bioenergie aus? 8.–9. September 2016, Leipzig. [online]. Leipzig: DBFZ. (Tagungsband, 3). ISBN: 978-3-946629-00-9. S. 120–125.

Publication: Matthes, M.; Hartmann, I.; Groll, A.; Riebel, U. (2016). "Investigation on application and performance of emission reduction measures at a pellet boiler". Biomass Conversion and Biorefinery (ISSN: 2190-6815), Vol. 6, H. 3. S. 301–313. DOI: 10.1007/s13399-015-0187-1.

Publication: Stolze, B.; Titus, J.; Schunk, S. A.; Milanov, A.; Schwab, E.; Gläser, R. (2016). "Stability of Ni/SiO2-ZrO2 catalysts towards steaming and coking in the dry reforming of methane with carbon dioxide". Frontiers of Chemical Science and Engineering (ISSN: 2095-0179), Vol. 10, H. 2. S. 281–293. DOI: 10.1007/s11705-016-1568-0.

Project summary

Term:	1 July 2015–31 December 2017
Project partner:	Deutsches Biomasseforschungszentrum (DBFZ), Helmholtz Centre for Environmental Research – UFZ, Emission Partner GmbH & Co. KG
Scientific contact:	Saad Butt, Dr. Ingo Hartmann
Project number:	16KN041428
Funding body:	VDI/VDE

* Abbreviations:

VOC: Volatile Organic Compounds
PAH Polycyclic Aromatic Hydrocarbons
CO: Carbon monoxide

Head of the research focus area

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E-Mail: ingo.hartmann@dbfz.de

4 COOPERATION AND NETWORKING

R&D COOPERATION WITH LOCAL INDUSTRY

The applied research and development work of the DBFZ is carried out in close cooperation with industrial partners. This ensures the necessary practical orientation, as well as providing detailed insights into markets, so enabling a focus on innovative and realisable solutions. The DBFZ assures the adoption of a neutral, holistic view in cooperation projects with industry. This approach enables the DBFZ to apply its extensive expertise to market-oriented R&D projects. Intensive participation by business is a requirement – and is the norm – in third-party funded projects particularly. To that end, the DBFZ's research departments maintain extensive national and international links with companies which carry out R&D in the relevant fields, as well as with bioenergy sector networks. In addition to its outstanding regional networking links within the Leipzig Energy and Environ-

Fig. 20 The DBFZ is a member of the BMBF BioEconomy Leadership Cluster

ment Cluster (NEU e. V.) and memberships of R&D networks such as "Energy Saxony e. V.", the DBFZ is also actively involved in research clusters such as the BMBF BioEconomy Leadership Cluster. The DBFZ also seeks to participate on a permanent basis in other research clusters and to handle specific subject areas in state-wide multiplier organisations. Through its Innovation Coordination scientific administration department, the DBFZ actively interlinks industrial and scientific players, such as in the course of specially funded subject-specific innovation forums aimed at creating institutionalised innovation networks.

SCIENTIFIC COOPERATION WITH CENTRES OF HIGHER EDUCATION

Scientific cooperation with centres of higher education and other research establishments in the field of biomass use as an energy and integrated material source is an essential element of the DBFZ's research work. The focus of activities is on realising the defined research goals based on applied research and development. Subsidiary topics are considered in conjunction with partners, so as to spread the relevant knowledge as broadly as possible. The aim is to create stable scientific networks based on active interchange between key national and international partners in the field of bioenergy research and development and bioeconomics.

Ongoing collaboration with permanent partners is also maintained in particular with regard to basic research and in areas in which the DBFZ has not yet established detailed specialist expertise. A strategic cooperation exists with the Helmholtz Centre for Environmental Research – UFZ to carry out the necessary basic research relating to assessment of bioenergy systems and into the microbiological principles underlying biochemical processes. As part of the cooperation, the DBFZ's Bioenergy Systems research department works closely with the UFZ's Bioenergy Department. Additionally, the DBFZ's Biochemical Conversion research department works closely with the UFZ's Microbiology Department. An intensive and strategic cooperation exists between the DBFZ's research focus areas and the Department of Waste and Material Flow Management of the University of Rostock (ASW), represented by the Scientific Managing Director of the DBFZ, Prof. Dr. mont. Michael Nelles, relating to the recycling of organic wastes and residues for

Fig. 21 The 10th Rostock Bioenergy Forum in cooperation with the DBFZ (16–17 June 2016)

energy use. In 2016, a number of joint projects were acquired, and a wide range of (peer-reviewed) scientific papers were published. Additionally, in cooperation with the Research Coordination administration department, eight doctoral candidates (as per: February 2017) are being supervised, and joint events are being hosted, such as the 10th Rostock Bioenergy Forum.

Fig. 22 SMILE Workshop/Business Canvas Model

THE DBFZ IN THE LEIPZIG-BASED STARTUP-NETWORK "SMILE"

Since 2015, the DBFZ has been a member of the Leipzig-based start-up network "SMILE" (Self-Management Initiative LEipzig). As a business coach, Ronny Kittler supports the transfer of research results for further development by start-ups or spin-offs in incubators such as at the Leipzig Bioenergy Innovation Centre. In order to stimulate an entrepreneurial culture at the DBFZ, regular workshops and match-making events are organised. Additionally, researchers' start-up projects are backed by mentoring, and the realisation of business ideas is supported by submitting applications for grant funding and drawing up business plans.

Ideas Workshop: BMBF "New products for the bioeconomy" tender programme

The Ideas Workshop has created a space for scientists, businesses and doctoral candidates to present and develop their ideas for new bioeconomy products and establish teams for the project phases. The full-day event aided this process in two ways. In the first part of the event, the latest trends in bioeconomics and life-cycle management were presented, along with best-practice examples and details of relevant grant funding programmes. In the second part, the approximately 35 attendees actively participated in two workshops, presented their ideas, discussed them, and established links with potential cooperation partners. At the two events, held in January and June 2016, a total of four innovative project ideas were developed and succeeded in gaining approval for grant funding:

- Insulating materials from agricultural residues (DBFZ)
- Fermentation tubing (DBFZ)
- Biogas capsule (UFZ)
- Carboxylic acids from fermentation (DBFZ/UFZ)

Table 1 SMILE events in 2016

Date	Event name
19 January 2016	Ideas Workshop: New products for the bioeconomy
25 April 2016	Workshop: From a patent to a start-up idea – Recycling strategies for energy and environmental technologists
29 June 2016	Ideas Workshop: New products for the bioeconomy/ Bioeconomy meets Circular Economy – Residues and waste materials for the bio-based products of tomorrow
9 September 2016	Workshop: From the lab to market – Making bioenergy concepts competitive
11 October 2016	Science-based start-ups – Grant funding programmes & Practical examples
22 October 2016	Workshop: Leadership Cluster meets leading-edge design in cooperation with GISBERT
14–15 November 2016	German Start-up Week 2016: "FORSCHUNGerGRÜNDEN"

SMILE PUBLICATIONS IN 2016

Additional information (in german language):
www.dbfz.de/smile
www.smile.uni-leipzig.de
www.dbfz.de/referenzen-publikationen/tagungsbaende

Europäische Union
Europa fördert Sachsen
ESF Europäischer Sozialfonds
smile.medibiz Zugang zu Markt und Finanzen
Leipziger Stiftung für Innovation und Technologietransfer

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5
EXECUTIVE SUPPORT TEAM

"The world of science is becoming ever more complex and dynamic. Good management is therefore a key factor in the success of scientific establishments looking to survive and prosper in the international competitive environment."

Dr. Nikolaus Blum, Commercial Director of the Helmholtz Centre Munich

The DBFZ's administration departments (Executive support team) report directly to the Scientific Managing Director Prof. Dr. mont. Michael Nelles. Alongside the Press and Public Relations department, the Research, Innovation and International Knowledge and Technology Transfer coordinators work closely with the four DBFZ research departments and the five research focus areas of the DBFZ. The aims are to utilise synergies in strategic research and project management, consortium creation and internationalisation for the entire research centre.

Fig. 23 Representatives of the scientific administration departments and colleagues from the Press and Public Relations department at the DBFZ (6 March 2017)

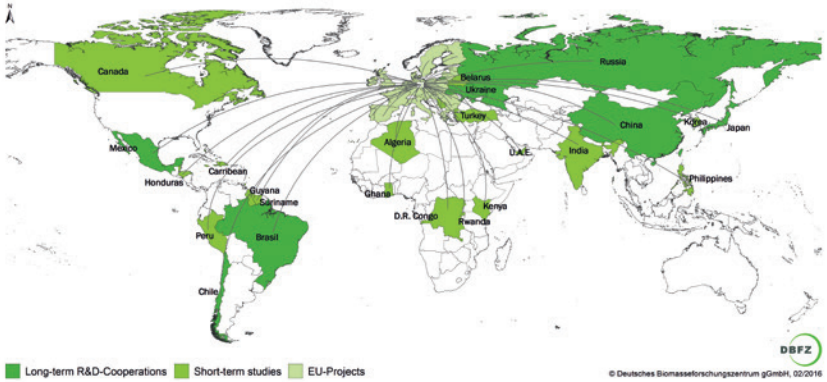

Fig. 24 International cooperation activities of the DBFZ

INTERNATIONAL KNOWLEDGE AND TECHNOLOGY TRANSFER

International activities play a key role within the DBFZ. The task of the International Knowledge and Technology Transfer administration department is to make the accumulated expertise of the DBFZ accessible to interested partners worldwide through joint research projects, exchange of doctoral candidates and reciprocal research secondments. A further task is to support and selectively expand the international network. This work also includes proposing and arranging reciprocal visits by decision-makers, and organising international workshops and conferences. Additionally, it seeks to further intensify cooperation with leading international universities and extramural research institutions.

Cooperation in Chile and South Africa

In 2016 the DBFZ continued its long-term cooperation with the University of Talca in Chile. A particular aim, alongside exchanging young scientists, is to enhance project collaboration. As one example, in the coming years a low-cost, low-emission stove will be developed which will help to ease environmental emission (primarily fine dust concentrations in the Andes valleys). Another international cooperation,


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Fig. 25 The DBFZ in the German-Chinese Biogas Consortium

with the University of Stellenbosch, an internationally respected leading academic centre in South Africa, seeks to promote exchange of doctoral candidates, thereby continuing the existing cooperation between Stellenbosch and Leipzig (in the form of a joint masters programme with the University of Leipzig). It also aims to promote scientific cooperation in the fields of biogas, potential and market analysis, bioenergy data, and modelling of biorefinery concepts.

Networking activities in China, Japan and India

In 2016, the DBFZ was one of just 15 leading institutions worldwide to be successfully certified by the Chinese State Administration of Foreign Experts Affairs (SAFEA). This entitles the DBFZ to offer education and training courses in China. Cooperation with the German Society for International Cooperation (GIZ) was also intensified in 2016. In combination with the possibility of in-house contract award, the opportunity now opens up to work together even more intensively than before on bioenergy projects in the countries concerned. Specific projects in Bosnia-Herzegovina, Vietnam and Indonesia have already been initiated under the new con-

tract award regime. Activities in India were also expanded further during 2016. The country is home to almost 20 % of the world's population, and any wide-area climate protection measures have a corresponding leverage effect. Against that background, the DBFZ and the University of Rostock's Department of Waste and Material Flow Management (ASW) co-hosted India's leading scientific waste management conference. The 6th International Conference on Waste Management (IconWM) in Calcutta attracted almost 600 participants from the scientific, industrial practice and policy-making spheres.

Memorandum of Understanding on German-Japanese research cooperation

On March 14, 2016, representatives of the DBFZ and of the Japanese Forestry and Forest Products Research Institute (FFPRI) signed a Memorandum of Understanding (MoU) signalling their intent to engage in a joint research project, and

Fig. 26 Successful cooperation agreement with the Japanese Forestry and Forest Products Research Institute (14 March 2016)

committing to farther-reaching cooperation relating to the torrefication of biomass. The MoU set forth a specific cooperation agreement on the economic assessment of torrefication applied in low-capacity conversion plants. The MoU additionally forms the basis for more intensive cooperation between the two research institutions aimed at exchanging experience gained, undertaking reciprocal research visits, carrying out joint work, and releasing joint publications.

Additional information:
www.dbfz.de/en/research-departments/international

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INNOVATION COORDINATION

Bioenergy and the associated technical solutions are increasingly being seen as part of the bioeconomy. In combined production from residue and by-product streams, they can supply the process energy for production processes for example. In combination with nutrient separation systems, they are also suitable as key elements in closing nutrient cycles. The potential applications of bioenergy technologies are opening up new fields of innovation. The Innovation Coordination scientific administration department is identifying and working on those fields. It links the DBFZ's application-related research to new partners and areas of application, and is continuously building the relevant networks. The research partners – mostly SMEs (small and medium-sized enterprises) – are integrated into those structures. They are open to all cooperation partners. Further tasks of the Innovation Coordinator relate to in-house invention management, exploitation of intellectual property rights, and technology and knowledge transfer.

Building and maintaining regional and international networks

Building and maintaining regional and cross-regional business and innovation networks, and ensuring the DBFZ's involvement in relevant projects, is one of the core tasks of the Innovation Coordinator. The DBFZ engages in the innovation landscape through the Leipzig Energy and Environment Cluster ("NEU – Netzwerk Energie & Umwelt e. V."), the "Energy Saxony e. V." state-wide energy body, and other innovation structures. As a means of providing small and medium-sized enterprises, in particular, with easier access to the DBFZ's research infrastructure, and developing joint R&D projects, the Innovation Centre for Bioenergy was established in 2014 in cooperation with NEU e. V. The incubator additionally provides interested companies and spin-offs with expertise in patent and brand protection, innovation financing, marketing, and grant application procedures.

BioEconomy Cluster · energy saxony · HTP Hydrothermale Prozesse · INNOVATIONSZENTRUM FÜR BIOENERGIE

NEU NETZWERK ENERGIE & UMWELT e.V. · TREC

Opening up new fields of innovation

A range of new innovation fields were opened up in 2016 in cooperation with the administration department. These included the link to the "Innovationsforum SpreuStroh" (innovation forum) on the use of field by-products, as well as the DBFZ's participation in innovation alliances such as "Innovative Wachstumskerne" (Innovative growth cores) in the field of nutrient recycling. The ongoing development of subject-specific innovation networks, such as the Hydrothermal Processes Innovation Forum, was also actively promoted during 2016, not least through the HTP forum held on September 8–9, 2016. In addition to opening up new fields of innovation and the relevant networking with the DBFZ, the administration department's agenda in 2016 also included expanding and integrating the DBFZ into cross-regional leading-edge research structures, such as the BMBF BioEconomy Leadership Cluster relating to the combined chemical, material and integrated energy use of beechwood. The acquisition of grant funding to build an interdisciplinary agricultural system research alliance was also pursued.

Internationalisation of innovation structures

Although the administration department's main focus is on building regional and national networks and research alliances, it continued to pursue various international projects in the past year. Particular attention was devoted to interlinking innovation networks within the BMBF-sponsored TREC project. The Danube region is one of the macro-regions for which the EU has created a dedicated

Fig. 27 TREC workshop on "Rural value creation networks" (28–29 November 2016 in Leipzig)

development strategy. All the regions along the EU's largest river are striving to work closely together. The Danube region includes priority agricultural areas with as yet unused biomass potential for the bioeconomy of the future. The administration department was also represented with papers presented at various bioeconomy conferences in Budapest, Bratislava, Belgrade and Lodz, and had a paper presented at IFAT, the leading resource and waste management fair in Munich.

Additional information (in german language):
www.dbfz.de/web/forschung/kooperationen
www.innovationszentrum-bioenergie.de
www.energiemetropole-leipzig.de/de/schwerpunkte/bioenergie
www.trec-network.eu

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RESEARCH COORDINATION

The Research Coordination administration department supports and coordinates links among scientists between the DBFZ's various disciplines and research departments, as well as with other research institutions. It aims to utilise in-house synergies and expertise, and to prepare the grounds for specific research cooperation projects. Among the key tasks of the Research Coordination administration department are:

- Monitoring of medium- and long-term research planning
- Supporting and evaluating the interdisciplinary development of national and international project submissions

- Organising internal information and training on ongoing tenders, as well as making and managing project submissions
- Preparing, organising and supervising internal and external evaluations and supporting the Research Advisory Council
- Optimising the DBFZ's scientific management and quality assurance based on good scientific practice
- Coordinating information exchange with and reporting to the institutional sponsor, the Federal Ministry of Food and Agriculture (BMEL), on research activities at the DBFZ
- Implementing the doctoral programme and supporting the DBFZ's doctoral candidates

In 2016, in addition to organising the doctoral programme, the administration department was mainly concerned with coordinating and fulfilling various internal and external reporting obligations, and evaluating the DBFZ's publication output.

Scientific Roadmap and German Council of Science and Humanities

In 2013, pursuant to a decision by the Federal Ministry of Food and Agriculture, the DBFZ was evaluated by the German Council of Science and Humanities (Wissenschaftsrat). Following an audit lasting about a year, the final assessment report for the 2010–2012 period under review confirmed that the DBFZ had undergone a successful establishment phase and exhibited "impressive expertise in the field of biomass use". In its subsequent approximately 40-page report published in 2016, "Implementation of the recommendations from the recent evaluation of DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH", the DBFZ responded to the proposals set forth by the Wissenschaftsrat and reported on the status of their implementation.
The 100-page "DBFZ Research Focus Roadmap", likewise drawn up in 2016, sets out the strategic planning and implementation of the DBFZ's "Smart Bioenergy" concept, together with the scientific goals of the five research focus areas. In addition to setting out the strategic goals of the research focus areas, the internal document lays down the fundamental scientific principles and research goals of

the DBFZ, provides an overview of its research partners, presents the measures carried out and results obtained from a SWOT analysis, as well as covering many other aspects. The DBFZ Research Focus Roadmap serves as an internal instrument of strategic development as well as a basis for discussions at the annual meeting of the DBFZ's Research Advisory Council.

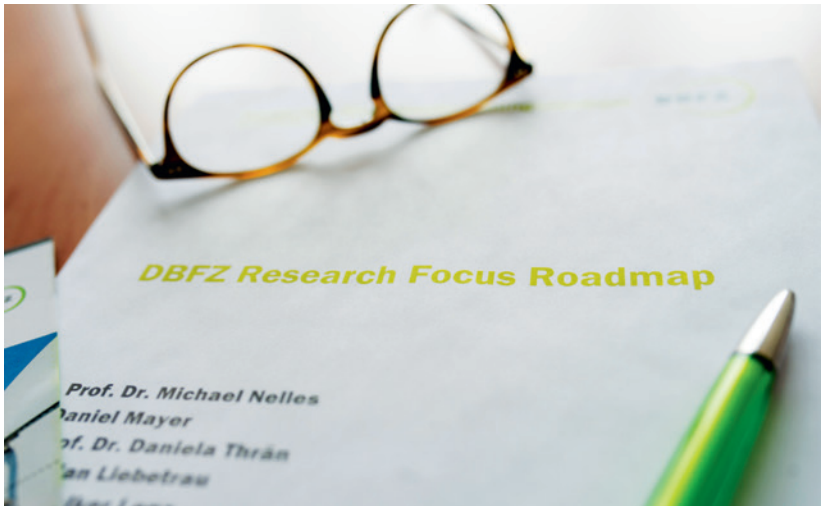

Fig. 28 The DBFZ Research Focus Roadmap sets out the medium- to long-term research goals of the DBFZ

Scientific publications (peer-reviewed/open-access)

A new record for publications of scientific papers was achieved in 2016. The 17 open-access publications by DBFZ scientists represented a particularly strong increase over the previous year. In total, DBFZ staff wrote and published 62 (peer-reviewed) scientific papers in the past year. A overview of all the publications is presented in the appendix to this Annual Report starting on page 165.

Fig. 29 Attendees at the 4th doctoral candidates' seminar at the DBFZ (8 March 2016)

Doctoral candidates' seminar

The doctoral candidates' seminar is a key element of the DBFZ's doctoral programme. It provides a forum for detailed scientific discussion of the results of doctoral work, as well as for interchange between the doctoral candidates and their internal and external supervisors. On March 8, 2016, some 30 participants attended the fourth doctoral candidates' seminar to be held at the DBFZ. Seven doctoral candidates presented the current status of their work. As well as engaging in scientific discussions, the attendees were once again called upon to vote for the best presentation. Jörg Kretzschmar (head of the DBFZ "Process monitoring and simulation" working group) won a 50 euro book token for his presentation on "The potential and challenges of using electroactive microorganisms for biogas process monitoring".

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6 DOCTORAL PROGRAMME

A key aspect of work to promote young scientists is the DBFZ's doctoral programme, which marks its fifth anniversary in February 2017. There are currently already 50 doctoral projects in progress at, and in cooperation with, the DBFZ. The DBFZ is collaborating on them with 14 universities and one polytechnical institute in Germany and three universities outside Germany. 17 of the doctoral projects are being run in cooperation with the Leipzig-based Helmholtz Centre for Environmental Research – UFZ. A new cooperation agreement with the UFZ (running from 2015 to 2024) stipulates closer cooperation on doctoral work as one of its provisions. The DBFZ especially promotes and supports on-the-job continuing professional development. Sixteen members of staff acquired their doctorates while working for the organisation. With the aim of increasing the predominance of research-related, industrially oriented topics of future impact in dissertations, and offering outstanding scientists the opportunity to acquire their doctorates under ideal conditions, in 2016 a concept for the structuring of the DBFZ's doctoral programme was devised, discussed and agreed with the DBFZ management and its doctoral candidates. The structured concept is scheduled to be finalised and implemented in 2017.

EXAMPLE DOCTORAL THESIS BY DR. ERIC BILLIG (COMPLETED)

Assessment of the technical and economic development potential of future and existing biomass-to-methane conversion processes

Biomass can be converted into methane by various routes. The two most widespread and best researched methods are biochemical and thermochemical conversion. In biochemical conversion, primarily lignin-light, mostly moist, biomass is converted by anaerobic digestion. The biogas product mainly comprises methane and CO_2. After separating out the CO_2, what remains is highly concentrated methane. In the industry this is usually designated biomethane. Thermochemical conversion, on the other hand, primarily uses lignin-rich biomass. It is converted into a synthesis gas by means of gasification. A downstream gas purification and mechanisation phase converts the synthesis gas into methane.

Fig. 30 Dr. Eric Billig

After a further processing step, the remaining substance here, too, is highly concentrated methane – in the industry usually designated bio-SNG (Synthetic Natural Gas).
So both conversion paths can be used to create the same product (methane), though from different biomass. A core question considered in the completed doctoral thesis was how such technologies – which create the same product, but are based on different biomasses and processes – can be assessed and compared. The thesis also considered the question of how those technologies will develop in future.
An extensive methodology was developed to answer the core questions. It incorporates a technical-economic assessment of the two conversion routes, as well as a learning curve to assess future development. To be able to make a verifiable comparison of the two conversion paths, straw was applied as the reference substrate. The properties of straw make it well suited to use in both technologies (biochemical and thermochemical conversion). The technical-economic assessment includes a multi-criteria analysis, a Delphi survey, and an evaluation of the technology alternatives (66 biochemical, 33 thermochemical). The learning curve was plotted on the basis of the available biomass potential in Europe, the learning rate of the technology, and the potential expansion of plant installations.

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Fig. 31 Biogas treatment plant with biomethane supply

Publications

Billig, E.; Thrän, D. (2016). "Evaluation of biomethane technologies in Europe: Technical concepts under the scope of a Delphi-Survey embedded in a multi-criteria analysis". Energy (ISSN: 0360-5442), H. 114. S. 1176–1186. DOI: 10.1016/j.energy.2016.08.084

Billig, E. (2016). Bewertung technischer und wirtschaftlicher Entwicklungspotenziale künftiger und bestehender Biomasse-zu-Methan-Konversionsprozesse: Dissertationsschrift. (DBFZ-Report, 26). Leipzig: DBFZ. XI, 210 S. ISBN: 978-3-946629-03-0

Horschig, T.; Billig, E.; Thrän, D. (2016). "Model-based estimation of market potential for Bio-SNG in the German biomethane market until 2030 within a system dynamics approach". Agronomy Research (ISSN: 1406-894X), Vol. 14, H. 3. S. 754–767.

Billig, E.; Witt, J.; Klemm, M.; Kirsten, C.; Khalsa, J. H. A.; Thrän, D. (2015). Intermediate biofuels to support a flexible application of biomass. In: Thrän, D. (Hrsg.) Smart Bioenergy: Technologies and concepts for a more flexible bioenergy provision in future. Cham (Schweiz): Springer. ISBN: 978-3-319-16192-1. S. 121–140.

Table 2 List of ongoing doctoral theses at the DBFZ, excluding cooperation partners UFZ/University of Rostock (as per: February 2017)

Name	Dissertation subject	Institution	Type of doctorate
Bdour, Mathhar Abdelmahdi	Development of combined heat, power and cooling system based on agricultural residues and biogenic waste	University of Rostock	Doctorate (grant)
Bindig, René	Cleaning of waste gases from small-scale biomass furnaces on innovative monolithic catalysts	University of Leipzig	Doctorate (on-the-job)
Bloche-Daub, Karina	Regional added value from the use of biomass as an energy source material	University of Leipzig	Doctorate (work programme)
Butt, Saad	High-temperature oxidation of pollutants on solid state catalysts	University of Leipzig	Doctorate (on-the-job)
Büchner, Daniel	Optimised control strategies for combination pellet/solar plants to improve system efficiency while minimising environmental impact	Technical University of Dresden	Doctorate (on-the-job)
Dernbecher, Andrea	Method for modelling thermochemical biomass conversion in a CFD-based simulation	Technical University of Berlin	Doctorate (work programme)
Dietrich, Sebastian	Trialling and intensification of a process for alkene synthesis from biogas and wind-H2	*	Doctoral placement In third-party funded research project
Dotzauer, Martin	Numeric input/output model of plants for electricity generation from biomass in Germany and derivation of medium-term trend scenarios	Leipzig University of Applied Sciences (HTWK)	Doctorate (on-the-job, cumulative)
Gallegos, Daniela	Potential of water plants for water cleaning and sustainable energy production for Mexico	University of Rostock	Doctorate (grant)
Gröngröft, Arne	Optimising the conversion efficiency of bioethanol refineries	Technical University of Hamburg	Doctorate (on-the-job)
Herrmann, André	Combined high-temperature fuel gas cleaning by moving-bed reactor (topic currently being adapted)	Technical University of Hamburg	Doctorate (on-the-job)
Horschig, Thomas	Use of system dynamics for modelling the German and European biomethane markets	University of Leipzig	Doctorate (work programme)
Janke, Leandro	Biogas from residual materials from the sugar and ethanol industry in Brazil	University of Rostock	Doctorate (grant)
Kirsten, Claudia	Contribution to optimising the pelleting behaviour of fermentation residues and landscape conservation hay and their mixtures	Technical University Bergakademie Freiberg	Doctorate (on-the-job)
Koch, Christian	Development of a new non-thermal plasma process for the high-efficiency treatment of non-volatile species from the thermochemical conversion of biomass	University of Leipzig	Doctorate (grant)
Köchermann, Jakob	Hydrothermal conversion of wood pulp solutions for the production of furan derivatives	*	Doctoral placement In third-party funded research project
König, Mario	Catalytically aided reduction of gaseous and particulate emissions from wood burning in Chilean households	University of Leipzig/University of Talca	Doctorate (on-the-job)
Kretzschmar, Jörg	Development of an electrochemical sensor platform for biogas reactors	Technical University of Dresden	Doctorate (work rogramme)
Kröger, Michael	Thermo-chemical utilisation of algae focused on hydrothermal processes	University of Rostock	Doctorate (on-the-job)
Krüger, Dennis	Development and system integration of a micro-combined heat and power plant for solid biomass	Technical University of Chemnitz	Doctorate (on-the-job)
Lauer, Markus	Macro-economic assessment of biogas plants as an option to enhance flexibility in the electricity system of the future	University of Leipzig	Doctorate (work programme)
Matthes, Mirjam	Emissions reduction in small-scale biomass furnaces based on integrated catalysis	Leipzig University of Applied Sciences (HTWK)	Doctorate (on-the-job)

Name	Dissertation subject	Institution	Type of doctorate
Matthischke, Steffi	Load flexibility of catalytic reactors based on the example of the methanation of carbon oxides	Technical University of Clausthal	Doctorate (grant)
Mauky, Eric	On-demand biogas supply based on process control	University of Rostock	Doctorate (on-the-job)
Müller, Liane	Improving the efficiency of the anaerobic degradation of nitrogen-rich compounds by the use of enzymes	University of Rostock	Doctorate (on-the-job)
Nitzsche, Roy	Adsorption and membrane filtration for the treatment of aqueous product solutions in lignocellulose biorefineries	Technical University of Berlin	Doctoral placement In third-party funded research project
Rönsch, Cornelia	Development of a method for utilising chimney-sweeping trade data for energy reporting	University of Leipzig	Doctorate (work programme)
Schlüter, Michael	Optimising methane yield in heterogeneous catalysed methanation at reduced temperatures and pressures by targeted balance shifting	University of Rostock	Doctorate (work programme)
Seidler, Andreas	Trace substance analysis by time and location in biomass solid fuel furnaces by means of laser mass spectrometry	University of Rostock	Doctorate (external)
Zeng, Thomas	Targeted treatment of wood-type biomass residues For use as fuel in small-scale furnaces for heat supply	University of Rostock	Doctorate (on-the-job)

* Currently being fine-tuned

7 PRESS AND PUBLIC RELATIONS ACTIVITIES

Press and public relations activities mediating between applied bioenergy research and the wider scientific community once again played a major role in the work of the DBFZ in 2016. As well as presenting its research results at numerous scientific conferences, fairs and other events, the DBFZ also utilised media relations, issued various scientific publications and organised a host of guided tours of its facilities in order to demonstrate its work.

Fig. 32 Attendees and podium discussion at the 2016 DBFZ annual conference (8–9 September 2016)

EVENTS

At the invitation of Germany's President Joachim Gauck and the German Federal Environmental Foundation (DBU), the DBFZ exhibited at the Berlin Environment Week for the first time from June 7 to 8, 2016. At the Schlossgarten Bellevue venue, DBFZ scientists engaged in dialogue with numerous interested lay visitors on current research topics in the field of bioenergy. At the event's Forum 5 "Energy–Climate protection", recent research results obtained by the DBFZ in relation to emission reduction, innovative stove firing techniques and intelligent heat supply

Fig. 33 Environment Week in the Schlossgarten Bellevue (7–8 June 2016)

Table 3 Events organised by and involving the participation of the DBFZ (selection)

Date	Event name	Event type
23 February 2016	Biogas Forum: A future for existing biogas plants – a contradiction in terms?!	Forum
09 March 2016	7th Separator Forum: Particle separators in domestic furnaces	Forum
23 March 2016	Practicians' day as part of the Biogas Forum	Forum
14 April 2016	Info Day: Use of solid biofuels for heat supply to commerce and industry	Information event
16–17 June 2016	10th Rostock Bioenergy Forum: Bioenergy – flexible and fit for the future	Scientific conference (Cooperation)
24 June 2016	Leipzig "Long Night of the Sciences"	Public event
31 August 2016	Foundation laying at the DBFZ	Internal event
10 August 2016	Workshop: European harmonisation of methods to quantify methane emissions from biogas plants	Workshop
7 September 2016	Biofuel Forum: Germany as a groundbreaker in greenhouse gas emission quotas	Forum
2–3 November 2016	FVEE annual conference: Research for the transition to renewables – Reshaping the energy system	Scientific conference (Cooperation)
15–18 November 2016	Energy Decentral – International trade fair for innovative energy supply	Trade fair

(SmartBiomassHeat) were presented and discussed under the title “Smart Bioenergy – Innovations for a sustainable future”.
Under the motto “Smart Bioenergy – What will the renewable energy-based future be like?”, the DBFZ annual conference was one of the highlight events of the past year. In seven sessions, one plenary assembly and parallel events on “Hydrothermal processes” (HTP) and “Computational Fluid Dynamics and biomass thermochemical conversion (CFD)”, the conference held on September 8 and 9, 2016 once again presented and discussed wide-ranging aspects relating to the use of biomass as an energy source and for integrated material recycling.
Some 200 visitors attending the Leipzig forums were able to discover all about research topics such as flexibilisation, anaerobic processes, solid biofuels, catalytic emission control and intelligent biomass heating technologies (SmartBiomassHeat). Topics such as bioenergy systems and the competitiveness of bioenergy concepts were also part of the conference agenda. The next DBFZ annual conference will take place in Leipzig in Autumn 2018. For more information visit the conference website at: **www.bioenergiekonferenz.de**.
Numerous other events (scientific forums, attendance at fairs, conferences, public and in-house events) rounded off a highly intensive year in 2016. A selection of the key events in which the DBFZ participated is presented in table 3.

Additional information (in german language):
www.dbfz.de/veranstaltungen
www.flickr.com/photos/139453872@N08/albums
www.dbfz.de/aktuelles/veranstaltungsnewsletter

NATIONAL AND INTERNATIONAL VISITORS

A wide range of scientific, industrial and political delegations once again visited the DBFZ and its laboratories and test beds in 2016 to find out about the latest developments in bioenergy research. In addition to high-ranking ministerial visits on the occasion of the foundation laying, the DBFZ also hosted numerous international delegations and scientists from Mexico, Japan, Peru, Canada, Colombia, Nigeria, the USA, China, Brazil, Kenya, Vietnam and India. All the visitors were

Fig. 34 DBFZ's administrative Managing Director, Daniel Mayer, being interviewed by Leipzig media (31 August 2016)

visibly fascinated and impressed by the scientific expertise, high technical standards and intensive infrastructure improvements they experienced at the Leipzig research centre.

MEDIA RELATIONS

The topic of bioenergy and the innovative research methods of the DBFZ once again attracted the interest of a wide range of regional and cross-regional media outlets in 2016 (including Leipziger Volkszeitung, Freie Presse, Sächsische Zei-

tung, Deutschlandradio, Deutsche Welle, Mitteldeutscher Rundfunk, Radio Mephisto, etc.). The low-emission “Pellwood” stove aroused particularly strong media interest (see interview starting on page 9). The official foundation laying for the new technical centre and administration building on August 31, 2016 also saw the DBFZ being featured widely in the media. Some excerpts from media reporting over the past year are presented at the end of this Annual Report starting on page 189.

Additional information:
www.dbfz.de/presse
www.twitter.com/dbfz_de

PUBLICATIONS

A total of four new issues of the “DBFZ Report” series were published in both print and digital versions in the past year. The freely available DBFZ series thus totals 27 issues. Alongside the third edition of the “Biofuel sector monitor” (report no. 11), other topics featured in the DBFZ document series included “Biofuel production in Germany – Technical state of the art and optimisation methods” (report no. 22), “Assessment of biomass-to-methane conversion processes” (report no. 26), and an issue on the subject of “New-style low-emission stove” (report no. 27). The in-house support function for the BMWi “Biomass Energy Use” programme also once again issued various scientific publications, all of which are available free of charge on the Internet. In addition to the aforementioned publications, a total of five digital conference proceedings and readers accompanying DBFZ events were released in 2016. All issues of the DBFZ document series are available to download free of charge.

Downloads:
www.dbfz.de/en/publications
www.energetische-biomassenutzung.de/en/downloads/publications

Fig. 35 New issues of the DBFZ document series (selection)

DBFZ DOCUMENT SERIES: CONFERENCE PAPERS AND READERS (2016)

- Proceedings of the 2016 annual conference – ISBN: 978-3-946629-00-9
- Proceedings of the 2nd CFD Workshop – ISBN: 978-3-946629-07-8
- Reader of the 7th Separator Forum – ISBN: 978-3-9817707-7-3
- Reader of the Ideas Workshop:
  New products for the bioeconomy – ISBN: 978-3-946629-02-3
- Reader of the 2nd HTP Forum on “Bio-based hydrothermal processes – Technologies for material and energy use” – ISBN: 978-3-946629-06-1
  (published: 25 January 2017)

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8 CONTRACT RESEARCH AND SCIENCE-BASED SERVICES

As an institution primarily conducting applied research, the DBFZ seeks as a matter of policy to engage in close cooperation with project partners from industry, and offers an extensive portfolio of contract research and science-based services. They extend beyond the research focus areas, and are targeted at policy-makers, industrial clients, non-profit organisations, consultants and supervisory bodies. The work is handled on an interdepartmental and interdisciplinary basis, so that the entire expertise of the DBFZ can be deployed comprehensively and efficiently for the following consulting and technical services.

Fig. 36 Work in the DBFZ fuel technical centre

8.1
POLICY ADVICE

By its very nature, research into the sustainable use of biomass as a material and energy source covers a wide range of different subject areas and levels of analysis. These must be regularly collated and processed in order to provide targeted assistance and support to decision-makers in government and industry. In this context, the DBFZ offers a wide range of consulting services for policy decision-makers. They include, for example, long-term monitoring of trends in bioenergy markets (comprising various projects relating to power generation from biomass and use of biofuel) and, on that basis, support in framing policy instruments (e. g. EEG, EEWärmeG, Biokraft-NachV, etc.).

The services also offer targeted support to policy decision-makers through the compilation of commentaries (such as in connection with new legislation) and position papers (mainly concerning the current potential for use of biogenic waste and residues as energy source materials, the portfolio of waste wood plants, the use of heat, and the consequences of a change to the biofuel quota). In 2016 consulting support was provided to the Federal Ministry of Food and Agriculture in negotiations on the 2017 amendment to Germany's Renewable Energies Act (EEG). The DBFZ's expertise in relation to the EEG amendment was also called upon by the Federal Ministry for Economic Affairs and Energy and by the federal states.

In addition to collecting, evaluating and presenting data and information on market trends, available biomass potential or the characteristic variables of available and future bioenergy technologies (costs, technical characteristics or potential environmental impact), in past years the DBFZ has also developed tools for devising medium- and long-term bioenergy scenarios as a means of strategy development (in the framework of the Milestones 2030 research project) and provides scientific support to strategic projects (mobility and motor fuel strategies).

Table 4 Key projects of the Policy Advice department in 2016 (selection)

Project	Commissioning party
Study on the ongoing development of the energy strategy of the Bundestag	German Lower House of Parliament (Bundestag)
Support to the JRC in developing new greenhouse gas emission standard values for biofuels	Expert Workshop, on invitation of the JRC (Joint Research Centre)
Nature conservation monitoring of the expansion of renewable energy sources in the electricity sector and development of instruments to reduce impairment of nature or landscape (in cooperation with the UFZ)	German Federal Nature Conservation Agency (BfN)
Consultancy project to develop a tender design for biomass plants	Federal Ministry of Food and Agriculture

OVERVIEW OF SERVICES

- Scientific support to strategic policy development and derivation of recommended action
- Commentaries on legislative procedures and support in their development
- Development and implementation of suitable monitoring systems under changing (research) policy framework conditions

Whereas policy advice seeks to cover the broadest possible range of issues in relation to biomass, the following consulting and other service offers are focused on selected topics and target groups.

Additonal information (in german language):
www.dbfz.de/referenzen-publikationen/statements
www.dbfz.de/referenzen-publikationen/studien

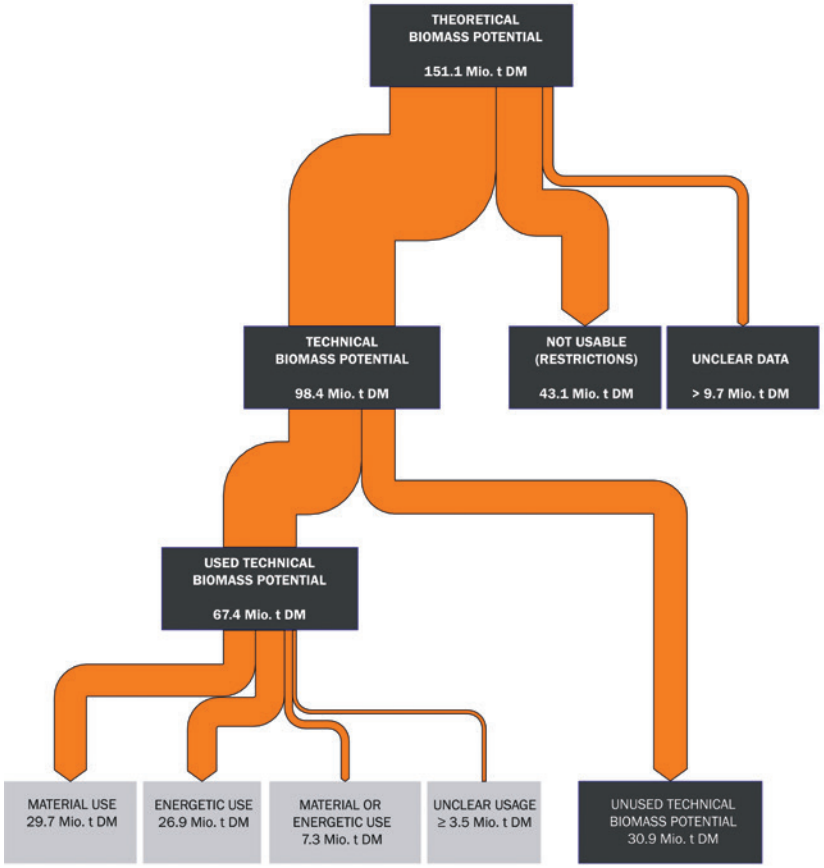
8.2 MARKET ANALYSES AND DATA PROVISION

Bioenergy continues to play a key role in the substitution of fossil fuels (FNR, 2016). Accordingly, the trend of recent years is being sustained, and both regional and international usage channels are being expanded further. With the parallel development of the bioeconomy sector, the number of players on the market potentially competing for the limited available biomass is rising. Against the background of steadily rising demands in terms of efficient usage technologies for sustainable bioenergy production and use, a comprehensive, up-to-date data set is the strategic key to customised planning and to the ongoing development of policy framework conditions. This includes depiction of trends in markets, as well as trading and raw material flows. The DBFZ is also pursuing the objective of providing technological, economic and ecological data for analysis and assessment of biomass production and supply concepts and technology options. A further possibility is to provide established and potential market players, and other interested parties, with transparent information on the continually rising quality and sustainability demands. Since February 2016, data management and provisioning at the DBFZ has been boosted by the establishment of a structured research data management system.

OVERVIEW OF SERVICES

- Determination of biomass potential and development of usage scenarios and recycling strategies for different players on biomass markets (material and energy use)
- Monitoring of market and technology trends, including systematic recording in databases, and drafting of market and technology overview reports

Biomass potentials of waste and residues and their actual use - Status Quo in Germany



Brosowski, A; Adler, P.; Erdmann, G. Stinner, W.; Thrän, D. Mantau, U.; Blanke, C.; Mahro, B.; Hering, T.; Reinholdt, G. (2015) Biomassepotenziale von Rest- und Abfallstoffen - Status Quo in Deutschland. Fachagentur Nachwachsende Rohstoffe e.V. (FNR). Gülzow-Prüzen - ISBN 978-3-942147-29-3

Fig. 37 Residual and waste material flows

- Forecasting future development trends in bioenergy and bioeconomics
- Data provision on biomass/bioenergy trading (costs, prices and quantities), and cost analysis of biomass production and supply (cost-supply curves)
- Provision of structural data on the power, heat and fuel market as well as analysis of the marketing strategies of plant and grid operators (e.g. for on-demand energy supply)
- Data provision on ecological and social aspects (e. g. emissions, environmental impact, sustainability indicators) and the policy-making framework

Depending on the question at hand, efficiency and sustainability analyses can be conducted in the course of economic, ecological and technical assessment and underpinned by sensitivity calculations and scenario analyses. This also applies to the evaluation of market and system integration concepts for flexible bioenergy supply.

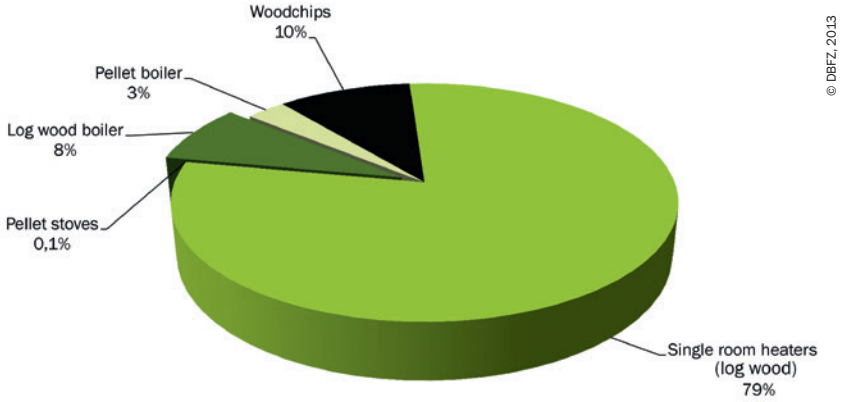


Fig. 38 The DBFZ produces large volumes of data on bioenergy use

8.3 TECHNICAL, ECONOMIC AND ECOLOGICAL ASSESSMENT

The increasing competition for limited biomass resources, allied to the continually rising and changing demands in terms of economic and ecological performance capability, is driving a rise in pressure on bioenergy plant operators to innovate and optimise. The DBFZ offers market players a range of services for the analysis and optimisation of existing and future bioenergy technologies and concepts. Alongside appraisals of the technical, economic and ecological characteristics of bioenergy plants, the analyses offered provide a suitable basis for process and concept optimisation.

OVERVIEW OF SERVICES

Technical evaluation

- Material and energy life cycle assessment
- Technical feasibility
- Technology screening and learning curves
- Characteristic data based evaluation (e. g. specific efficiencies, availabilities, quality level, classification by technical development status)

Economic evaluation

- Feasibility studies and assessment of usage/operating concepts including costs of new plant, plant upgrades or repurposing projects

- Cost and economic viability analyses for biogenic supply concepts (power, heat, fuels, chemical bioenergy sources)
- Analysis of value chains based on life cycle cost analyses (LCC, Social Life Cycle Assessment) and assessments as to the regional added value of the contribution of biomass usage concepts

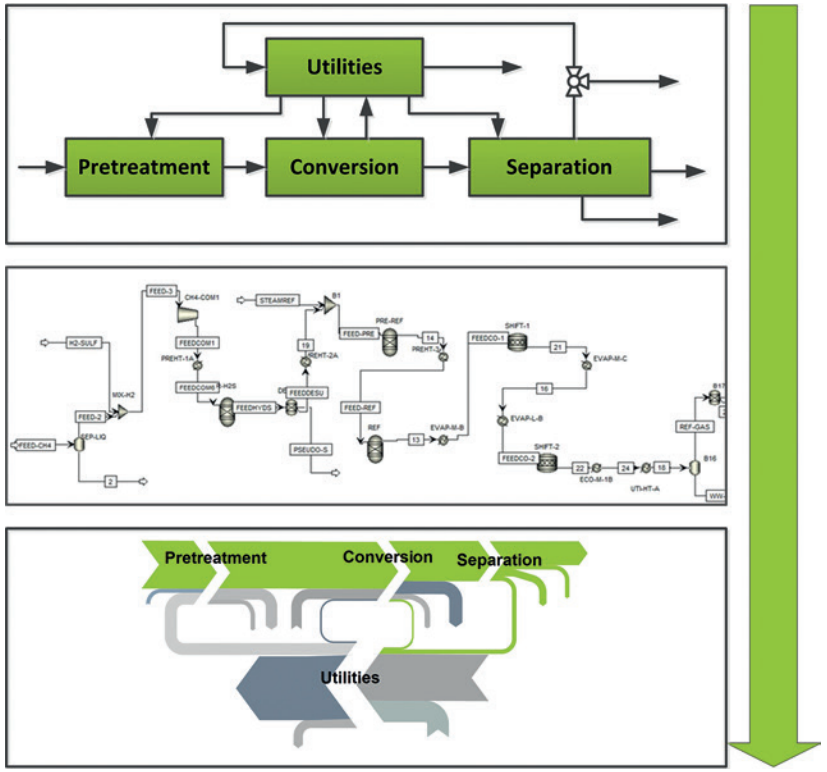


Fig. 39 From the plant design concept, through process simulation, to technical assessment

Ecological assessment

- Life cycle assessment (LCA) referred to greenhouse gas emissions and other environmental impact (including biological water balance, humus, eutrophication, acidification) as well as primary energy consumption
- Competing land use

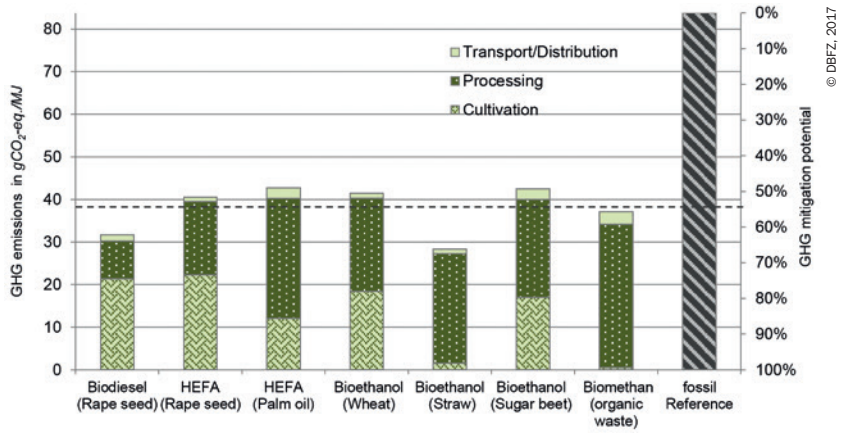


Fig. 40 Potential for greenhouse gas reduction of selected biofuels compared to the fossil fuel reference value of EU-RED (DBFZ Report 11)

8.4 CONCEPT AND PROCESS DEVELOPMENT AND OPTIMISATION

Concept and process development plays a key role in bioenergy research, as a means of meeting the challenges of changing political and social conditions. In-house practical developments in bioenergy form the basis for the services offered. Know-how on the technical state of the art is continually deployed in the ongoing advancement of processes. Key tools alongside in-house pilot plants are self-developed computer models for the calculation of material and energy flows. These relate to entire biorefineries, or to individual components such as incinerators, gasifiers and synthesisers. In this way, the experiments are supported and enriched by numeric calculations. Depending on the subject being investigated, process flow simulations, such as in Matlab and Aspen Plus, or CFD models in Open FOAM and Ansys CFD, are employed to provide a detailed understanding of processes and techniques and to enhance the predictive accuracy of the models.

Process flow simulations can be used to analyse the interactions of the various process steps. Analysis of mass and energy balances of complete or partial biorefineries in particular offers possibilities to enhance efficiency at an early stage. Additionally, the results provide a key basis for economic and ecological analyses. The effects of modifications to existing plants can also be effectively depicted by process flow simulations. CFD simulations depict plants of any scale three-dimensionally, enabling their physical-chemical processes to be analysed. This is particularly focused on investigating flow processes, taking into account the chemical reactions that are occurring. By varying parameters, the processes can be controlled and means of optimisation identified, for example to reduce emissions from furnaces or enhance the efficiency of synthesiser plants.

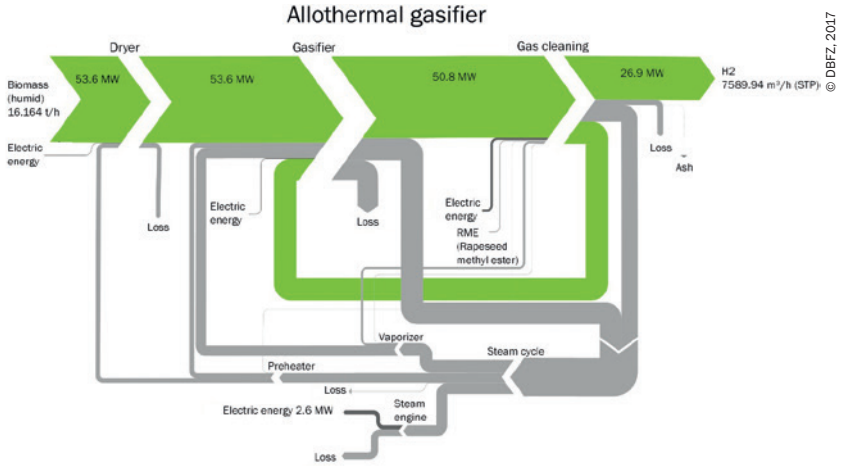


Fig. 41 Sankey diagram for a bioenergy plant producing hydrogen from moist biomass

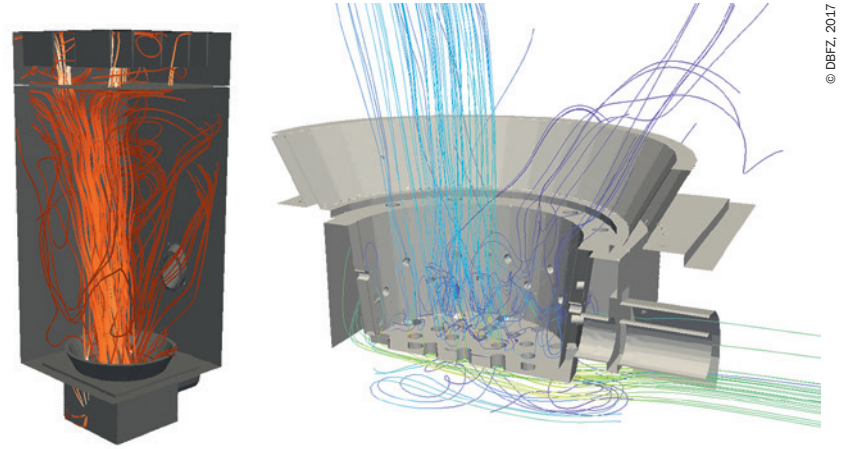


Fig. 42 Flow lines in a pellet boiler (left) and a pellet burner (right) from a CFD simulation

OVERVIEW OF SERVICES

- Development of new process concepts
- Calculation of material and energy flows (process balancing)
- Upscaling of processes
- Testing and development of new technologies and process steps
- Optimisation of existing technologies, process steps and material flow management concepts
- Producing CFD and process flow simulations (stationary and dynamic)
- Kinetics measurements for catalysts
- Development of control concepts

8.5
SCIENTIFIC SUPPORT TO R&D PROJECTS

The “Biomass Energy Use” programme sponsored by the Federal Ministry for Economic Affairs and Energy (BMWi) has been running at the DBFZ for the last eight years now as an example of successful scientific support to R&D projects. In the course of events such as scientific conferences and workshops, 112 projects and 295 project partners in the SME sector have to date been successfully interlinked by the programme. Other key aspects are the collation of the scientific output of the programme participants and the transfer of the results to various interested parties (in the fields of policy-making, research and practical application). To this end, a series of scientific papers was developed, to date comprising 20 volumes and five specialist booklets published on various keynote topics (biogas, solid fuels, hydrothermal processes, bioenergy technologies, etc.). The programme support activities also include organising the cross-project working groups as part of the process to harmonise scientific methods. So far, based on intensive discussions with the programme participants, the measurement methodologies relating to biogas and fine dust have been enhanced and a method handbook (in German and English) updated, and joint commentaries have been written.

OVERVIEW OF SERVICES

- Initiation of and scientific support to demo and pilot plants
- Accompanying scientific research on complex R&D projects
- Scientific advice and support to bioenergy initiatives of local authorities/ regions

Fig. 43 Series of scientific papers relating to the “Biomass Energy Use” programme

- Scientific support to research programmes by:
  - Interlinking between projects
  - Converging scientific output (press and public relations)
  - Enhancing visibility and presentation of programmes
- Coordination of cross-project working groups
- Coordination of events and compilation of publications
- Support to ongoing scientific and technical dialogue
- Coordination of harmonisation procedures

8.6 KNOWLEDGE AND TECHNOLOGY TRANSFER

The DBFZ offers comprehensive expertise in the field of knowledge and technology transfer. As well as hosting the Leipzig forums, this also includes organising conferences on specific focus topics (e.g. hydrothermal processes, process metrology of biogas plants, computational fluid dynamics CFD, dust collectors in domestic furnaces). In addition, the DBFZ issues numerous publications (concluding reports, dissertations, guides, handbooks and collections of conference proceedings, reports) providing an extensive portfolio of scientific reports which are made available free of charge on the Internet. The Bioenergy Innovation Centre manages and coordinates specific innovation processes as well as establishing and developing national and international networks. A wide range of cooperation projects in Germany and internationally also provide continuous knowledge and technology transfer in the form of workshops, guides and employee training courses.

OVERVIEW OF SERVICES

- Organisation and hosting of scientific and technical events (forums, conferences, workshops)
- Coordination of innovation processes
- Drafting of guidelines and handbooks
- Development and compilation of Web-based information platforms and open-source portals
- Training and development courses

Fig. 44 Attendees at the “Hydrothermal processes” forum (8–9 September 2016)

8.7
TECHNICAL-SCIENTIFIC SERVICES

Complementing the aforementioned services, the DBFZ offers a special R&D infrastructure in the three technical research departments: Biochemical Conversion, Thermo-Chemical Conversion and Biorefineries. Technical-scientific services are offered to plant and machinery manufacturers, process developers, plant operators and other companies and institutions carrying out R&D. A detailed listing of the various technical facilities on the DBFZ site can be found at the end of this Annual Report starting on page 142.

BIOCHEMICAL CONVERSION RESEARCH DEPARTMENT

The Biochemical Conversion department researches the production of energy source materials from biomass using micro-organisms. Its focus is on technologies for biogas recovery and use. It also considers the efficient use of material flows and closed nutrient circles, as well as supporting the demonstration of new and improved plants and components. All activities are undertaken against the background of detailed evaluation of the market and of the technical state of the art, assured by participation in various monitoring projects. As part of its intensive cooperation with the Helmholtz Centre for Environmental Research – UFZ, it also provides answers to wide-ranging questions relating to the properties of the micro-organisms involved and their population dynamics.

Fig. 45 Lowry protein assay at the DBFZ's biogas lab

THERMO-CHEMICAL CONVERSION RESEARCH DEPARTMENT

The Thermo-Chemical Conversion department handles a range of topics associated with the thermo-chemical conversion of biogenic solid fuels for the efficient, demand-oriented supply of heat and/or power as well as refrigeration. Research services can be offered all along the chain, from the fuel (preparation, conditioning, pelletisation), through the development and optimisation of furnaces and mini and micro CHP plants (including CFD assistance) also in conjunction with emission control measures (catalysis and separation), through to the control of single plants and system networks (also with other heat sources, as well as power grid integration). Additionally, laboratory and field emission tests (measuring dust CO and VOCs accredited in accordance with DIN EN ISO/IEC 17025:2005) can be performed, as can separator tests and catalyst tests, complete with discussion of results and assignment to specific bioenergy markets.

Fig. 46 The DBFZ's combustion lab

BIOREFINERIES RESEARCH DEPARTMENT

The core subjects of the Biorefineries department are processes for chemical bioenergy source materials and fuels. The focus is on efficient chains and innovative biorefinery concepts for synthesis gas and hydrothermal processes. This also includes implementation of conversion and separation systems in the technical centre, incorporating laboratory analytics for comprehensive chemical-physical characterisation of biomasses and productions as well as test bed investigations of the motor behaviour of liquid and gaseous biofuels. Activities are rounded off by technical assessment, costing and ecological evaluation of different master concepts for biorefineries or a wide range of different biofuels. Investigations also cover the balancing and optimisation of processes, as well as concepts based on stationary and dynamic flowchart simulations. Another aim is to initiate pilot/demonstration projects and monitor them scientifically.

ANALYTICAL LAB

In order to assess the potential applications of various biomasses, the DBFZ's analytical lab analyses the chemical composition and combustion properties of liquid fuels, solid biofuels, biogas substrates, by-products and residual materials, as well as their conversion products, such as ash, filtration dust and waste water. Based on current research projects, topics relating to glycerin analytics can also be covered. Analysis is carried out in accordance with commonly applied standards, although depending on a problem-oriented methodology. Based on the available equipment the following parameters can be determined: gross density, bulk density, particle size distribution, amount of fines, durability, gross/net calorific value, water content, volatiles, fixed carbon, ash content, elemental composition including major and minor elements, total content of sulfur and chlorine as well as elutable elements, density, viscosity, refraction index, flashpoint, pH value and distillation range. Polycyclic aromatic hydrocarbons (PAHs) and phenols can be identified and quantified with chromatographic equipment. Perspectively, the capability will be also available for fatty acid methyl esters (FAMEs), furane derivatives, volatile aromatic hydrocarbons (BTEX) and various sugars.

The central point of contact for the Contract Research and Science-based Services department is the DBFZ Innovation Coordinator, Romann Glowacki.

Contact

Romann Glowacki
Phone: +49 (0)341 2434-464
E-Mail: romann.glowacki@dbfz.de

9 ORGANISATION AND STRUCTURE

The Deutsches Biomasseforschungszentrum (German Biomass Research Centre; DBFZ for short) was established as a non-profit limited company in Berlin on February 28, 2008 with the aim to investigate and illuminate the complex issues relating to the supply and use of bioenergy. The DBFZ is a national scientific establishment of the Federal Republic of Germany, represented by the Federal Ministry of Food and Agriculture (BMEL).

Fig. 47 The DBFZ main building (building 6) with adjoining children's day nursery in Summer 2016

9.1
SCIENTIFIC MISSION

"The DBFZ was founded in 2008 by my ministry, the Federal Ministry of Food and Agriculture (BMEL). Back then, it was important to all stakeholders that this future-oriented research should be sited in one of the new federal states in eastern Germany. Leipzig proved to be the ideal location. The DBFZ's research focus areas underscore how important it is that we use our resources in a responsible manner, so as to safeguard our economic sustainability in future."

Christian Schmidt, Federal Minister of Food and Agriculture

The DBFZ was established by the former German Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) with the aim of establishing a central scientific research institution covering all the fields relevant to bioenergy and to bring together the findings of the highly diverse German research community in the sector. The scientific mission of the DBFZ is to support the efficient integration of biomass as a valuable resource for sustainable energy supply based on wide-ranging applied research. The mission incorporates technical, ecological, economic, social policy and energy business aspects all along the process chain, from production, through supply, to use. The DBFZ drives and supports the development of new processes, methodologies and concepts in close cooperation with industrial partners. It also maintains close links with public-sector research bodies in Germany in the agricultural, forestry and environmental sectors, as well as with European and global institutions. Working from this broad research base, the DBFZ is also tasked to devise scientifically sound decision-making aids for government policy-makers.

9.2 RESEARCH DEPARTMENTS

To provide the organisational framework for its wide-ranging scientific research activities, the DBFZ has four closely cooperating research departments. While the Biochemical Conversion, Thermo-Chemical Conversion and Biorefineries departments primarily conduct applied research, the Bioenergy Systems department provides policy advice as well as compiling potential analyses. acceptance studies and scenarios for biomass use.

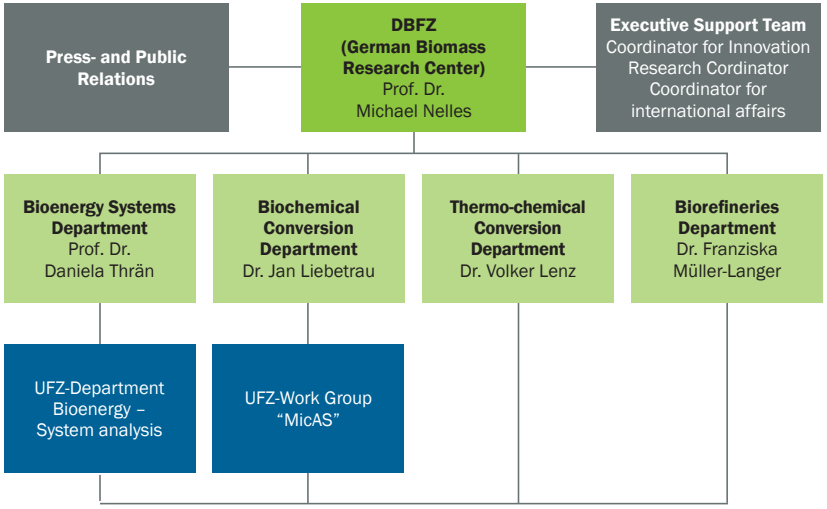


Fig. 48 The DBFZ research departments, including departments in cooperation with the UFZ

9.3 SUPERVISORY BOARD AND RESEARCH ADVISORY COUNCIL

The international Research Advisory Council (RAC) provides advice on the scientific work of the DBFZ. The Research Advisory Council comprises ten national and eight international bioenergy scientists of high repute. The members of the Research Advisory Council are appointed by the Supervisory Board, which is constituted of one representative each from the five federal ministries of primary importance to the DBFZ's work.

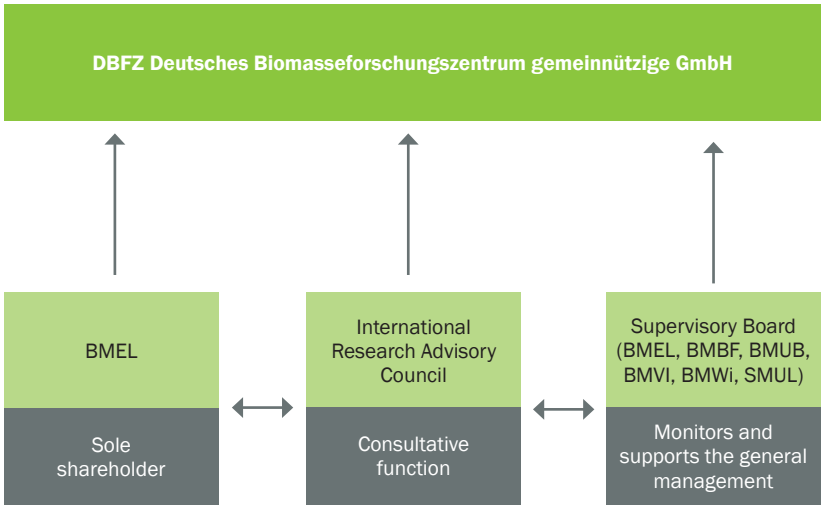


Fig. 49 The controlling bodies of the DBFZ

THE SUPERVISORY BOARD

The key substantive and organisational decisions relating to the development of the DBFZ are taken by the Supervisory Board, which is chaired by the Federal Ministry of Food and Agriculture (BMEL). Other members are the Federal Ministry of Education and Research (BMBF), the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB), the Federal Ministry of Transport and Digital Infrastructure (BMVI), the Federal Ministry for Economic Affairs and Energy (BMWi) and the Ministry of the Environment and Agriculture of the state of Saxony (SMUL).

Supervisory Board members:

(as per: 15 January 2017)

Bernt Farcke (Chairman)
Head of Department 52 “Sustainability, regrowable resources”,
Federal Ministry of Food and Agriculture (BMEL)

Deputy Director Berthold Goeke (Deputy Chairman)
Head of Department “KI I Climate Protection Policy”, Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)

Daniel Gellner
Head of Department “Agriculture and Forestry”,
Ministry of the Environment and Agriculture of the Free State of Saxony (SMUL)

Deputy Director General Dr. Dorothee Mühl
Head of Department III B Electric Power,
Federal Ministry for Economic Affairs and Energy (BMWi)

Dr. Christoph Rövekamp
Head of Division – Division 722 – Basic Energy Research,
Federal Ministry of Education and Research (BMBF)

Birgitta Worringen
Head of Department G2 – Sustainable Mobility, Energy, Logistics,
Federal Ministry of Transport and Digital Infrastructure (BMVI)

Fig. 50 The Supervisory Board of the DBFZ (11 May 2016)

THE RESEARCH ADVISORY COUNCIL

The international members of the Research Advisory Council advise the DBFZ on its scientific activities. This ensures that the institutionally funded research carried out is scientifically sound and of maximum relevance to the current and future use of bioenergy as part of the energy system.

Table 5 Research Advisory Council members (as per: 15 January 2017)

Member	Organisation	Location and country
Barbosa, PhD Maria	Microalgal Biotechnology Algae-PARC, Wageningen University	Wageningen (Netherlands)
Bauen, Dr. Ausilio	Imperial College London	London (England)
Bill, Prof. Dr. Ralf	University of Rostock – Faculty of Agricultural and Environmental Sciences	Rostock (Germany)
Chiaramonti, Prof. Dr. David (Chairman)	Renewable Energy Consortium R&D, University of Florence	Florence (Italy)
Christen, Prof. Dr. Olaf	Martin Luther University, Halle-Wittenberg	Halle/Saale (Germany)
Dach, Prof. Dr. Jacek	Poznan University of Life Sciences	Poznan (Poland)
Dong, Prof. Dr. Renjie	China Agricultural University (CAU)	Beijing (China)
Dornack, Prof. Dr. Christina	TU Dresden – Institute for Waste and Lifecycle Management	Dresden (Germany)
Hartmann, Dr. Hans	Technology and Promotion Centre at the Regrowable Resources Competence Centre (TFZ)	Straubing (Germany)
Hirth, Prof. Dr. Thomas	Karlsruhe Institute of Technology (KIT); University of Stuttgart – Faculty of Energy, Process Engineering and Biotech	Stuttgart (Germany)

Fig. 51 The Research Advisory Council of the DBFZ (29 November 2016)

Member	Organisation	Location and country
Kemfert, Prof. Dr. Claudia	German Institute for Economic Research (DIW Berlin)	Berlin (Germany)
Kruse, Prof. Dr. Andrea	University of Hohenheim, Stuttgart	Stuttgart (Germany)
Meyer, Prof. Dr. Bernd	Institute for Energy Process Engineering and Chemical Engineering, TU Mining Academy Freiberg	Freiberg (Germany)
Moreira, Dr. José Roberto	Universidade de São Paulo, Instituto de Eletrotécnica e Energia	São Paulo (Brazil)
Serrano, Prof. Dr. David	IMDEA Energy Institute	Madrid (Spain)
Teutsch, Prof. Dr. Georg	Helmholtz Centre for Environmental Research – UFZ	Leipzig (Germany)
Thiffault, PhD Evelyne	University Laval Canada Québec	Québec (Canada)
Walther, Prof. Dr. Grit	RWTH Aachen – Faculty of EconomicSciences	Aachen (Germany)

9.4
FINANCE AND PERSONNEL

The Deutsches Biomasseforschungszentrum (DBFZ) was established with the legal form of a “gemeinnützige GmbH” (non-profit limited company). This provides it with the necessary flexibility and transparency to obtain public research funding and also to carry out research and consulting operations on behalf of third parties. The DBFZ is financed by institutional funding from the BMEL as well as by competitively procured project grants and revenue from acquired research contracts.

In 2016, the BMEL provided the DBFZ with 11 million euros in funding, of which 4.3 million was earmarked for capital investment, with 3.5 million of that sum being allocated to the new building project. Some eight million euros in third-party funding was procured in 2016. Adjusted to take account of payments on account already received from projects, third-party source revenues totalled over 5.5 million euros, maintaining the previous years’ levels. In view of the difficult political climate with regard to bioenergy, the DBFZ has thus succeeded in bucking the trend.

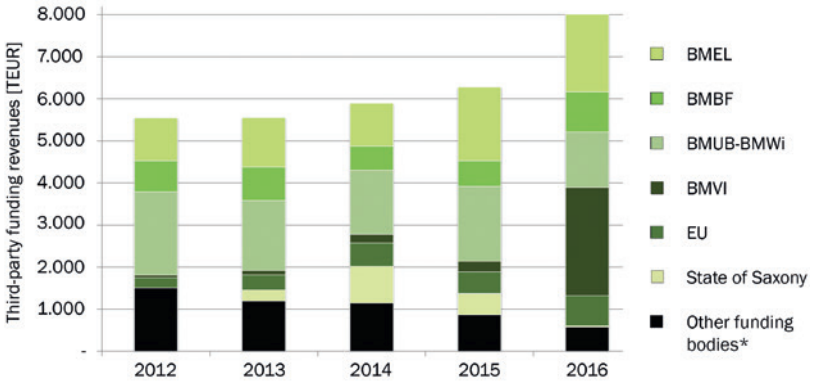


Fig. 52 Overview of third-party funding revenues from 2012 to 2016
(* Industrial contract research and services for private and public-sector clients)

Project revenues from grant funding totalling 5.1 million euros were on a par with the previous year’s level. In 2016, the principal expenditure of the DBFZ was its personnel cost, which accounted for some 49 % of total expenditure, followed by capital investments (34 %) and operating expenses (17 %). The high proportionate level of capital investment relates to the new building project (2015–2020).

PERSONNEL

The DBFZ employed 172 salaried staff on average in 2016. Including the scientific administration departments and the press and public relations staff, 133 people were employed in scientific/technical posts and 39 in administration (including Property, Infrastructure and IT).

A wide range of work was supervised at the DBFZ once again in 2016. A total of 26 intern and student study projects and 54 bachelors, masters and diploma dissertations were supervised. A total of 30 visiting scientists, foreign interns and grant-funded students also worked at the DBFZ in 2016.

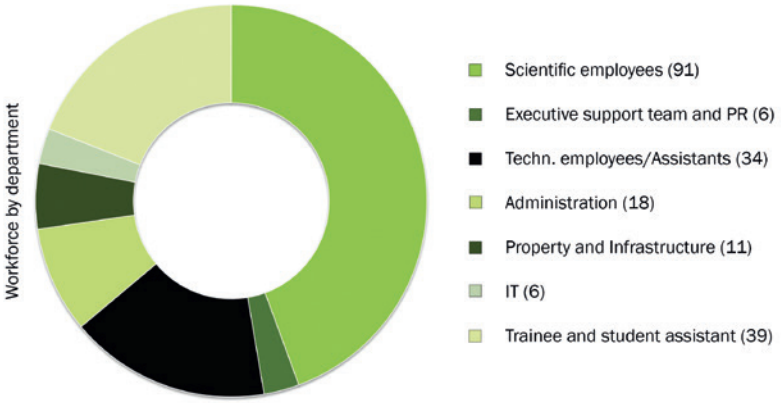


Fig. 53 Breakdown of the DBFZ workforce by department (as per: December 2016)

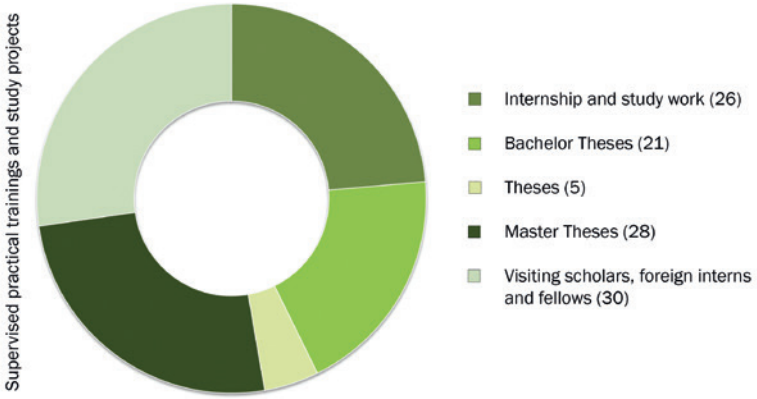


Fig. 54 Overview of work projects supervised at the DBFZ in 2016 (as per: February 2017)

TRAINEES AT THE DBFZ

The DBFZ has been an accredited training centre since its establishment in 2008. To date, a total of 16 trainees have successfully passed training and retraining courses. In 2016, four trainees were undergoing training in the areas of events management, office administration and electronic engineering, while three BA students were studying for degrees in environmental technology, informatics and controlling. Two trainees successfully qualified in 2016.

9.5 SCIENTIFIC BODIES, ADVISORY BOARDS AND COMMITTEES

The DBFZ seeks to maintain intensive knowledge transfer with other institutions and the scientific community at large. This is in keeping with its objectives of conducting applied research and utilising its results for practical benefit. To that end, DBFZ scientists are members of a wide variety of scientific bodies, advisory boards, working groups, networks and committees, as well as holding (visiting) professorships in Germany and abroad.

SCIENTIFIC ADVISORY BOARDS/MANAGEMENT BOARDS/ DIRECTORATES (SELECTION)

- aireg – Aviation Initiative for Renewable Energy in Germany e. V.
- Association of German engineers (VDI), Mecklenburg-Western Pomerania regional association
- BioEconomy e. V., BMBF BioEconomy Leadership Cluster
- Bioeconomy Council – independent consulting body to the German Federal Government
- Biomass to Power and Heat programme committee, Hochschule Zittau/Görlitz
- Biomass Use Competence Centre Schleswig-Holstein
- Bundesverband Bioenergie e. V. (BBE; German Federal Bioenergy Association)
- Chinese-German Centre for Environmental Technology and Knowledge Transfer (CETK) of the Province of Anhui, Hefei (China)
- DGAW – Deutsche Gesellschaft für Abfallwirtschaft e. V. (German Society for Waste Management)
- Energy Advisory Board of Saxony, state level

Fig. 55 Prof. Dr. Daniela Thrän at the Scientific Committee of the European Biomass Conference and Exhibition (EUBCE)

- Energy and Environmental Foundation Leipzig
- European Journal of Engineering and Natural Sciences (Member of the Editorial Board)
- Export Initiative RETech “Recycling & Waste Management in Germany” of the German Federal Government (BMUB, BMWi, BMZ)
- Förderkreis Abgasnachbehandlungstechnologien für Dieselmotoren e. V. (FAD) (Association for the promotion of waste gas final treatment technologies for diesel motors)
- German-Chinese Centre in the Province of Anhui (China)
- Helmholtz Centre for Environmental Research – UFZ
- Institute of Non-Conventional Chemistry (INC) at the University of Leipzig
- State Energy Council of Mecklenburg-Western Pomerania – Research & teaching
- Steering committee for 2nd stage of 1. BImSchV (Ordinance governing small and medium-sized furnaces under the Federal Immission Control Act) and head of Technology working group
- Scientific Advisory Board, European Biogas Association (EBA), Brussels (Belgium)
- Scientific Committee, Conference on Sustainable Energy and Environmental Development – SEED 2016, AGH University of Science and Technology Cracow (Poland)
- Scientific Committee International Scientific Conference and Workshops – Innovative Buildings (InBuild), AGH University of Science and Technology Cracow (Poland)
- Scientific Committee, 6th international Renewable Energy Congress Hammamet (Tunisia)
- Scientific Committee, International Conference on Sustainable Development Belgrade (Serbia)
- Scientific Committee, International Conference on Solid Waste: Knowledge Transfer for Sustainable Resource Management, Hong Kong (China)
- Scientific Committee, 5th International Conference on Solid Waste Management Bangalore (India)
- Scientific Committee, 2nd Workshop CFD Computational Fluid Dynamics and Biomass Thermochemical Conversion, Leipzig
- Senate and research leadership group of the German Federal Ministry of Food and Agriculture (BMEL)
- State of Mecklenburg-Western Pomerania Economic-Scientific Strategy Council (future field Energy & Environment)
- Scientific journal “Müll & Abfall” (Waste & Refuse)
- Scientific journal “Waste Management”
- ZIM network – Applications and research network for radio wave technology (RWTec)

WORKING GROUPS/COMMITTEES

- Ad Hoc working group on 1. BImSchV, German Federal Environmental Agency (UBA)
- Arbeitsgemeinschaft Stoffspezifische Abfallbehandlung, ASA e. V. (Working group on material-specific waste treatment)
- "Bioeconomy" working group of the Structural Commission on Technology Assessment and Design, Saxony Academy of Sciences, at state level
- "Blue Angel" working group, German Environmental Aid Programme (DUH)
- Cultural landscapes working group of the Landesheimatbund Sachsen-Anhalt e. V. (State of Saxony-Anhalt heritage association)
- Data management, Federal Institute of Risk Assessment (BfR)
- "Electric power" working group, "Biomass Energy Use" programme
- European Biofuels Technology Platform (EBTP), WG1 European Technology
- European Biofuels Technology Platform (EBTP), WG4 Policy and Sustainability
- IEA Bioenergy, Task 37 "Energy from Biogas"
- IEA Bioenergy, Task 39 "Commercializing Conventional & Advanced Liquid Biofuels from Biomass"
- IEA Bioenergy, Task 40 "Sustainable International Bioenergy Trade – Securing Supply and Demand"
- "Library Concepts" working group of the BMEL departmental research establishments
- "Material use" working group, German Energy Agency (DENA)
- "OpenAgrar" working group of the BMEL departmental research establishments
- Platform for Renewable Heating and Cooling (ETP-RHC)
- ProcessNet – Sustainable Production, Energy and Resources (SuPER), "Energieverfahrenstechnik" (Energy process engineering)
- ProcessNet – Sustainable Production, Energy and Resources (SuPER), "High-temperature engineering"
- ProcessNet – Sustainable Production, Energy and Resources (SuPER), "Integrated material and energy use of biomass"
- ProcessNet – Sustainable Production, Energy and Resources (SuPER), "Alternative fuels"
- Sustainability working group, Fachverband Holzenergie (association for the promotion of energy from wood)

- Think Tank research community, Helmholtz-Gemeinschaft UFZ
- "Life-cycle assessment" working group, "Biomass Energy Use" programme

DIN/ISO STANDARDISATION COMMITTEES (SELECTION)

- CEN/TC 230/WG 23 "Aquatic macrophytes and algae"
- DIN: NA 172 "Standardisation committee: Basics of environmental protection (NAGUS)"
- DIN: NA 172-00-10 "Sustainability criteria for biomass" subcommittee
- DIN: NA 062-05-82 "Solid biofuels" subcommittee
- DIN: 33999 "Dust collector testing" working group
- ISO committee 238, ISO/TC 255 "Solid Biofuels"
- ISO TC 238 WG7 + WG4 + WG1 + WG2 + WG4 + WG5
- ISO standardisation committee ISO/TC 255 "Biogas"
- VDI 3461 "Emission control of the thermo-chemical gasification of biomass in cogeneration"
- VDI 3475-3 Emission control; plants for the mechanical and Biological treatment of municipal waste"
- VDI 3670 "Waste gas purification – downstream dust reduction systems for small and medium small-scale furnaces for solid fuels"
- VDI 4630 "Digestion of organic substances – Substrate characterisation, sampling, material data acquisition, fermentation experiments"
- VDI/DIN: Working group on the production of biocarbonisates, Kommission Reinhaltung der Luft (Clean Air Commission)

PROFESSORSHIPS

- Environmental Management in the Department of Economic Engineering, Ernst-Abbe-Hochschule (EAH), Jena
- Faculty of Agricultural and Environmental Sciences, University of Rostock
- Faculty of Energy and Environmental Sciences, Shenyang Aerospace University (China)

- Faculty of Environmental Technology and Biotechnology, University of Hefei (China)
- Institute of Renewable Energy, China Petroleum University Beijing (China)
- Institute for Infrastructure and Resource Management, Department of Bioenergy Systems, University of Leipzig

Fig. 56 Dr. Stefan Rönsch has been teaching as a professor at the Ernst-Abbe-Hochschule (EAH) in Jena since February 2016

NETWORKS/ASSOCIATIONS/PLATFORMS (SELECTION)

- Association of German Engineers (VDI)
- Biofuels Research Network (ForNeBIK)
- BioRaf network (www.bioraf-netzwerk.de)
- Combustion Institute (German section)
- DECHEMA, “NawaRo” regrowable resources working group
- DECHEMA Society for Chemical Technology and Biotechnology
- Dena Biogaspartner (German Energy Agency)
- Energy and Environment Network (NEU e. V.) – Bioenergy Cluster
- Energy Raw Materials Network (ERN)
- Energy committee of the Leipzig Chamber of Commerce and Industry (CCI)
- Energy Saxony – The Energy Cluster for Saxony (network initiative)
- International Energy Agency (IEA)
- KUP network
- Renewables Research Alliance (FVEE)
- Sustainable Development Solutions Network (SDSN)
- The Bioeconomy Stakeholders PanelRAL – Bundesgütegemeinschaft Brennholz (Federal fuel wood quality control group)
- VGB PowerTech e. V.

Fig. 57 Excavation pit for the new office building and event centre on the DBFZ site (Autumn 2016)

9.6 CONSTRUCTION MEASURES AND FOUNDATION LAYING

There have been intensive construction and renovation works at the DBFZ facility in the Schönefeld district of Leipzig over the last five years. After the building infrastructure had undergone extensive upgrading in 2011 and 2012 as part of the second round of the government's economic stimulus programme, mainly to improve its energy efficiency, in 2013, attention turned to the planning and installation of an on-site children's day nursery as well as preparations for the major redevelopment featuring a large-scale technical centre and a timber-framed combined event centre and office block. The DBFZ's children's day nursery was completed in July 2013. It provides 10 fully staffed places for children aged from 1 to 3, with 16 office workstations on the upper floor. In conjunction with a wide range of other family-friendly provisions, this enabled the DBFZ to acquire a "Beruf und Familie" certificate in 2014 documenting its visible and tangible attainment of a healthy work-life balance.

NEW BUILDING COMPLEX WITH TECHNICAL CENTRE, LABORATORY, ADMINISTRATION AREA AND SEMINAR FACILITIES

In 2013, the DBFZ and the then Federal Ministry of Transport, Construction and Urban Development (BMVBS), represented by the Saxony State Ministry of Finance (SMF) and the Saxony State Real Estate and Facility Management Agency, Leipzig I office (SIB), announced the launch of a competition to design and build a new technical centre. From a total of 56 applicants, 25 were selected following the first phase. Of those, 23 submitted competitive proposals. The design by the consortium of Schulz & Schulz Architects and MLT consulting engineers emerged

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Fig. 58 Simulation of the new building seen from Torgauer Strasse towards the city centre (left) and from the DBFZ site towards Torgauer Strasse (right)

as winner of the contest, and has been under construction since the summer of 2013 by the Schulz & Schulz/MLT "Deutsches Biomasseforschungszentrum" consortium. To create space for the new building, some initial demolition of parts of the existing structure was undertaken in 2015.

The DBFZ's new building complex comprises a fivestoried office and seminar block and a twostoried technical centre and laboratory. At the heart of the complex is the technical centre for measuring and testing as part of research and development work into new fuels and incinerator plants, pellet processing, and waste gas analysis. The technical centre and laboratory block is divided into three areas. Each area incorporates an approximately 800 m^2 pilot plant room, housing test beds and assemblies of varying configurations. All the pilot plant rooms have dedicated laboratory and storage facilities. An imposing reception area, an extensive seminar room for up to 222 people and various functional and meeting rooms will be installed on the ground floor of the office and seminar building by the end of 2018. The four upper floors will house offices, all providing for a high degree of flexibility. The structure and the facade are in a sustainable and innovative wood design. The total cost of the new building project is 56 million euros, funded by the Federal Ministry of Food and Agriculture on behalf of the German federal government.

31 AUGUST 2016: OFFICIAL FOUNDATION LAYING AT THE DBFZ

The foundation stone for the new building was laid on August 31, 2016 in the presence of the Federal Minister of of Food and Agriculture, Christian Schmidt, Governor of the state of Saxony, Stanislaw Tillich, State Secretary Gunther Adler and Leipzig City Councillor responsible for economy and employment, Uwe Albrecht. The placing of items in the time capsule and the symbolic hammer blow marked the launch of the construction phase of the new building which had been in planning since Autumn 2013.

Fig. 59 High-ranking ministerial visit on the occasion of the foundation laying ceremony at the DBFZ: State Secretary Gunther Adler, Federal Minister Christian Schmidt, Governor Stanislaw Tillich, Leipzig City Councillor responsible for economy and employment Uwe Albrecht (left to right)

Speaking in front of some 250 invited guests and DBFZ staff, the Minister asserted the importance of bioenergy in the transition to renewable energy, and encouraged the further expansion of biomass research in Leipzig: "Shifting the energy economy away from fossil fuels to renewables, and integrating bioenergy into the bioeconomy of the future, are among the most vital challenges of our time. Application-oriented research and development in relation to the use of regrowable resources as an energy and material source within the bioeconomy is the central role of the DBFZ in Leipzig. With today's ceremony, we are not only laying down the foundation stone for a new building, we are also strengthening the foundations for future research into biomass. The new building complex at the DBFZ demonstrates that biomass is a key resource – for today, and for the future," Christian Schmidt remarked.

The welcome speech to the foundation laying ceremony and lots more information on the DBFZ construction project can be found in the brochure titled "GRUNDSTEINLEGUNG NEUBAU 31. AUGUST 2016" (New building foundation laying ceremony, 31 August 2016).

Download (in german language):
www.dbfz.de/referenzen-publikationen/broschueren

10 TECHNICAL EQUIPMENT

The DBFZ has at its disposal a wide range of technical systems, test beds, laboratories and scientific tools. The following lists the available capacities.

RESEARCH BIOGAS PLANT

The biogas pilot plant extends the range of application-oriented research being carried out at the DBFZ to enhance process understanding and improve the efficiency of biogas production. The dimensioning of the fermenters allows experiments to be conducted on a technical scale, so ensuring good transferability of results into practice. The facility features two independent lines with identical capacity which can be operated as a multi-stage system. The first line is a wet fermenter with a main fermenter in the form of a stationary stirred tank with a central agitator. The second line can optionally be run with a main fermenter of identical design or

Fig. 60 The DBFZ's biogas pilot plant

with a plug-flow fermenter. A post-digester with a gas reservoir cover collects the fermentation residues from both lines and routes them to the fermentation residue store. The biogas is used in a CHP (combined heat and power) plant with an electric power output of 75 kW to cover the facility's own energy demand. Surplus power can be fed into the DBFZ grid. The generated heat is used solely to meet in-house demand. For substrate supply, small amounts of silage can be stored on-site. To measure the gas production volumes precisely, individual fermenters are fitted with permanent covers. Terminal units in the pipeline system and at the gas capture point permit sampling and the installation of measuring instruments.

BIOGAS LAB

The biogas lab is designed and equipped to simulate large-scale technical processes on a laboratory and semi-technical scale, complete with the corresponding analytics. Its aims are to optimise processes and to improve the basic understanding of the individual processes involved in methane formation. It operates extensive (continuous and discontinuous) pilot plants with reaction volumes between 0.25 and 500 litres, as well as the biogas pilot plant. It investigates a variety of substrate mixes from agriculture, the waste management sector and industry on behalf of research and industrial partners. Alongside in-process analytics, the instrumental analytic's function is one of its key areas of activity. Resources available to the scientists include high-performance

Fig. 61 Fully-mixed stirred-tank reactors in the DBFZ biogas lab

liquid chromatography (HPLC) as well as gas chromatographs (GCs) for analysis of interim products. The cooperation agreement with the Helmholtz Centre for Environmental Research – UFZ means microbiological analyses are also possible. As well as laboratory simulation and the associated stationary systems, resources also include various instruments for conducting field measurements. In combination, these resources enable the efficiency and emissions of large-scale plants to be assessed.

EMISSION MEASUREMENTS

The Biochemical Conversion department has an extensive range of measuring instruments for the identification of diffuse methane leakages. The portfolio includes an infrared camera capable of visualising methane losses in real time, a methane laser, as well as various hand-held instruments with which are able to detect methane emission point sources. There is also an extensive range of equipment for quantifying climate-related emissions, from both conducted and diffuse sources. Methodological resources include open/dynamic and closed/static chambers. Optical remote sensing methods can also be employed to determine emissions based on tunable diode laser absorption spectrometry and dispersion models. The department also has at its disposal explosion-proof sensors and methods for the continuous monitoring of operational methane emissions from pressure relief valves.

ANALYTICAL LAB

The analytical lab is equipped with the following devices for the characterization of liquid fuels, solid biofuels, biogas substrates, by-products and residual materials, as well as their conversion products, such as ash, filtration dust and waste water: a Karl Fischer headspace titrator; a bomb calorimeter; a Stabinger viscometer; ion chromatography; elementary analysis; EC/OC; ICP-OES; an flashpoint analyser; a copper corrosion test; microwave digestion systems and a freeze dryer. The lab additionally features a UV-VIS spectrometer, a refractom-

Fig. 62 Work in the DBFZ's analytical lab

eter, and two GC-MS units to identify and quantify organic components (e. g. phenols) as well as a HPLC, which will propectively be used to analyse sugars and furan derivatives.

FUEL TECHNICAL CENTRE

The DBFZ's fuel technical centre investigates and develops the key process steps to convert (aqueous) biomass flows into solid (e. g. biocoal), liquid (motor fuels) and gaseous (e. g. methane) bioenergy sources and base chemicals. A wide range of test beds for the investigation of hydrothermal processes (HTC/HTV), biomass gasification, gas purification and catalytic synthesis, as well as for a variety of

treatment technologies, are available for research tasks and service contract work. Experimental results are also applied to complete and validate process and plant simulations. For the hydrothermal laboratory experiments, the DBFZ operates three batch reactors (2x 500 mL, 1x 10 L), a continuous tubular reactor and a two-stage continuous test facility. In addition to the screening of a wide variety of different biomasses, extensive experiments are conducted to determine the dependency of the yield and composition of the products on the reaction parameters. The liquid and solid (interim) products are analysed with regard to their chemical composition and fuel properties in the DBFZ's analytical lab.

An entrained-flow gasifier and a fixed-bed gasifier are available for investigation of the biomass gasification process. The entrained-flow gasifier converts biomass with particle diameters below 1 mm into a synthesis gas with low tar content at temperatures of up to 1,200 °C and under atmospheric pressure with air and oxygen as the gasification agents. The fixed-bed gasifier is rated for temperatures up to 1,050 °C, pressures up to 20 bar and variably selectable mixtures of oxygen, nitrogen, air, water vapour and CO_2 as the gasification agents. As well as gravimetric monitoring of the fixed bed over time, the temperatures and gas compositions can be measured in situ along the length of the bed. Sampling enables tar components to be kept in the gaseous state for analysis. Two different gas purification systems round off the gasification test beds. A heatable three-chamber system is available for different sorbents, as is a mobile small-scale pilot plant for the two-stage hot detarring of product gases.

Four fixed-bed reactors (three tube reactors and one plate reactor) are currently being used to research the catalytic conversion of synthesis gas into fuels and base chemicals such as methane (SNG) and short-chained alkenes.

The temperatures of one tube reactor and one plate reactor are controlled by thermal oil. Water vapour content and chemical toxicity (e. g. H_2S) can be directed into the reactor system to test their influence on the reaction. The aim is to investigate the dynamic reactor behaviour and the product gas composition in response to fluctuating synthesis gas qualities and volume flows (e. g. Power-to-Gas) as well as the catalyst deactivation. Thanks to the wide temperature and pressure window ($T \leq 850$ °C, $p \leq 60$ bar) of the plants, different reactor concepts and operating conditions, as well as conventional and innovative catalysts, can be directly compared.

Fig. 63 Fixed-bed gasifier at the DBFZ's fuel technical centre

Fig. 64 New decanter test bed at the DBFZ's fuel technical centre

Different processing technologies for substrates from upstream conversion steps, such as fermentation, hydrothermal or hydrotreatment processes, are investigated on innovative apparatus. This involves the use of solid-liquid and liquid-liquid separation processes. Continuous two-phase separation of product streams, even below 100 L h^{-1}, is possible using the decanter test bed, equipped with online TS measurement and weighing systems. Solid-liquid separation is supplemented by hydraulic hot dewatering for solid-rich suspensions. It is suitable for heavily water-binding substances, and offers the advantage of being able to dewater hot intermediate streams directly with no upstream cooling. The extraction process utilises the differing solubility properties of substances. It is used primarily in recovering valuable products from fermentation broths. The membrane filtration system can be used for analysis in the micro-, ultra- and nano-filtration range as well as in reverse osmosis. It permits membrane screening

in wide pressure, temperature and pH value ranges. Using preparative HPLC, various valuable products such as sugars, furans, phenols or carboxylic acids can be highly selectively separated across a broad application range at high flow rates and pressures.

ENGINE TEST BED

In response to the complex demands on motor fuels in the transport sector, the DBFZ operates an engine test bed for research purposes. The primary aim is to test new-style renewables-based fuels in combustion engines. Specifically, the single-cylinder research engine is used to test thermodynamic implementation (such as power output and consumption), legally limited and unlimited pollutants, engine oil dilution and the application of exhaust gas cleaning systems in terms of the fuel. A variety of different measurement and analytical techniques are used. Exhaust emissions can be measured by FTIR spectrometer, smoke meter, PMD, FID, lambda meter and NDIR, among other methods. Further analytical facilities are available in conjunction with the in-house analytical lab. The combustion process is analysed by a high-pressure indicating system, with online visualisation. Moreover, a freely programmable automation system enables typical engine properties such as speed, load, rail pressure, charge air pressure, engine oil temperature and coolant temperature to be freely configured and continuously recorded (up to 100 Hz). The modular design of the test bed also enables modifications to combustion engines to be implemented quickly and autonomously.

In order to more effectively assess the high demands on exhaust gas cleaning systems when using renewable fuels, the DBFZ's "Diesel cat ageing" project – sponsored by the Forschungsvereinigung Verbrennungskraftmaschinen e. V. (Research Association for Combustion Engines e. V. (FVV)) and Fachagentur Nachwachsende Rohstoffe e. V. (FNR) – has developed a laboratory-scale catalyst ageing test bed which is capable in particular of testing the durability of exhaust gas cleaning components (e.g. diesel oxidation catalysts or SCR catalysts). The exhaust gas is produced by a burner rather than by a combustion engine. Various other (synthesis) gases can also be added to the electrically heated ex-

haust tract. There are also a various add-ons, such as exhaust gas recirculation and external exhaust gas cooling. The temperature, pressure, volumetric flow and exhaust gas composition are logged all along the exhaust tract by a PLC. A four-sample fixture is currently being used as catalyst canning for simultaneous ageing of four sample catalyst bodies. The test bed thus permits analysis of catalysts' suitability in relation to various motor fuels and fuel grades right from their development phase.

With a view to the steady progression of electromobility in Germany, technical potential can be analysed on a specially-built test bed for range-extender modules (range-extenders extend the range of plug-in electric vehicles while driving). Regeneratively powered electric vehicles combined with regeneratively-powered range-extender modules can help to dispel prejudices against electromobility and at the same time open up opportunities for new-style fuels which are only available regionally in small quantities. The installed test bed can be applied to a variety of set-ups thanks to its modular design.

TECHNICAL CENTRE WITH 12 COMBUSTION TEST BEDS

In the combustion lab, the DBFZ conducts experiments on raw or pre-conditioned biomass by means of thermo-chemical conversion. It is also able to carry out de-

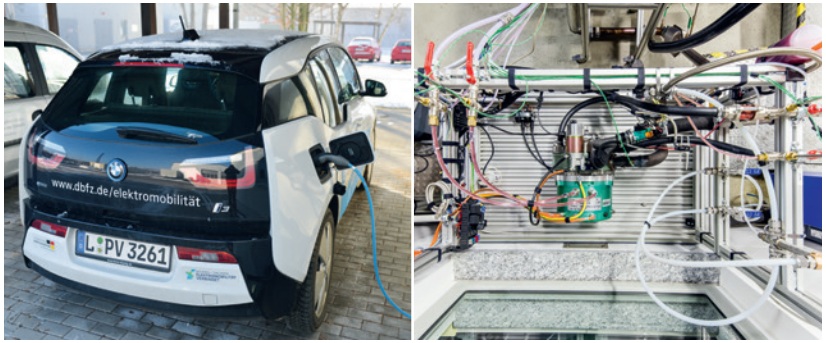

Fig. 65 Electric BMW and range extender

tailed analysis of exhaust gas emissions and particulate formation processes. The combustion lab is equipped with a full-flow dilution tunnel test bed, a separator test bed with variable volumetric flow, a tiled stove test bed, a catalytic converter development stand, 15 exhaust analysers (including FTIR, SMPS, exposition chamber) and seven dust measurement devices as well as six boiler vessels on various different experimental setups.

FUEL CONDITIONING AND COMBUSTION LAB

Based on its extensive and widely respected experience and know-how, the DBFZ's fuel conditioning and combustion lab together with its analytical lab conduct a wide variety of tests and experiments in close cooperation with leading scientific and industrial partners. Fuel conditioning experiments can be performed on a wide variety of different fuels. A warehouse facility covering an area of over 800 m² currently holds more than 150 different fuel variants. The fuel conditioning and combustion lab has dedicated conditioning systems and a new 30 kW ring-matrix press with which it conducts experiments in the production of new-style biogenic solid fuels, particularly including fuel mixes. The pellets produced can be fully characterised in accordance with European standards governing solid biofuels.

Fig. 66 Fuel conditioning and combustion lab and materials hall with over 150 fuel variants

DATABASES

The “System contribution of biomass” research focus collects wide-ranging data to monitor trends on the bioenergy market in close interaction with other DBFZ research focus areas. The data includes technical and economic information, details relating to licensing law and information of relevance to stakeholders, such as for the German bioenergy plant portfolio or on market trends in biogenic raw materials and fuels. In many cases time-series charts are provided, based on the DBFZ’s years of monitoring in the field of bioenergy supply and use. For systematic data acquisition and analysis, standardised data management tools, including various database systems, are utilised – in some cases combined with geographical information systems (GIS). Based on the available data relating to the bioenergy plant portfolio in Germany and to international raw material and fuel markets and trading flows, the DBFZ offers private and public-sector decision-makers top-class consulting services on strategic policy issues and market-related decision-making. The extensive and systematically expanded data base enables them to assess market dynamics against the background of changing framework conditions and predict future development trends.

ASSESSMENT METHODS

The limited biomass potential must be utilised efficiently to safeguard the long-term future of the energy system. In view of the many and varied properties and usage options of biomass, methods and tools are required to manage the sectoral deployment of biomass in accordance with social needs (such as for climate protection or to deliver system services). To that end, the “System contribution of biomass” research focus devises and develops methods for assessing the technical, ecological, social and economic effects of biomass use for energy production. The development of dynamic scenarios offers the possibility to assign the results within various contexts. In conjunction with the DBFZ’s database of current bioenergy technologies, they can be deployed to support decision-makers in the political and business spheres.

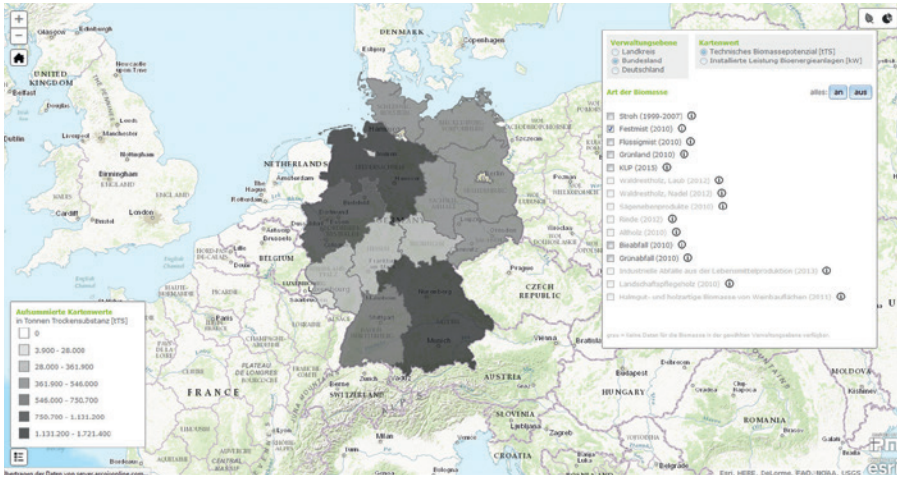

Fig. 67 Interactive bioenergy atlas identifying biomass potential

POTENTIAL ANALYSES

In order to assess the availability of sustainable raw materials and residues, the DBFZ is developing a far-reaching model which can be used to calculate regional, national and international biomass potential for energy production. Tools employed include geographic information systems (GIS) to localise biomass potential. Scenarios are then developed in conjunction with the latest statistics, official base geo-data and freely available geo-data. Alongside freely accessible information, a joint project enables a large number of individual topics to be covered specific to the needs of the client concerned.

Additional information (in german language):
www.dbfz.de/biomassepotenziale

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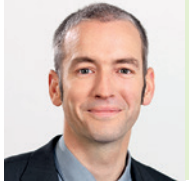

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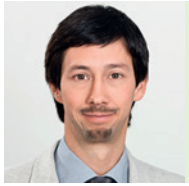

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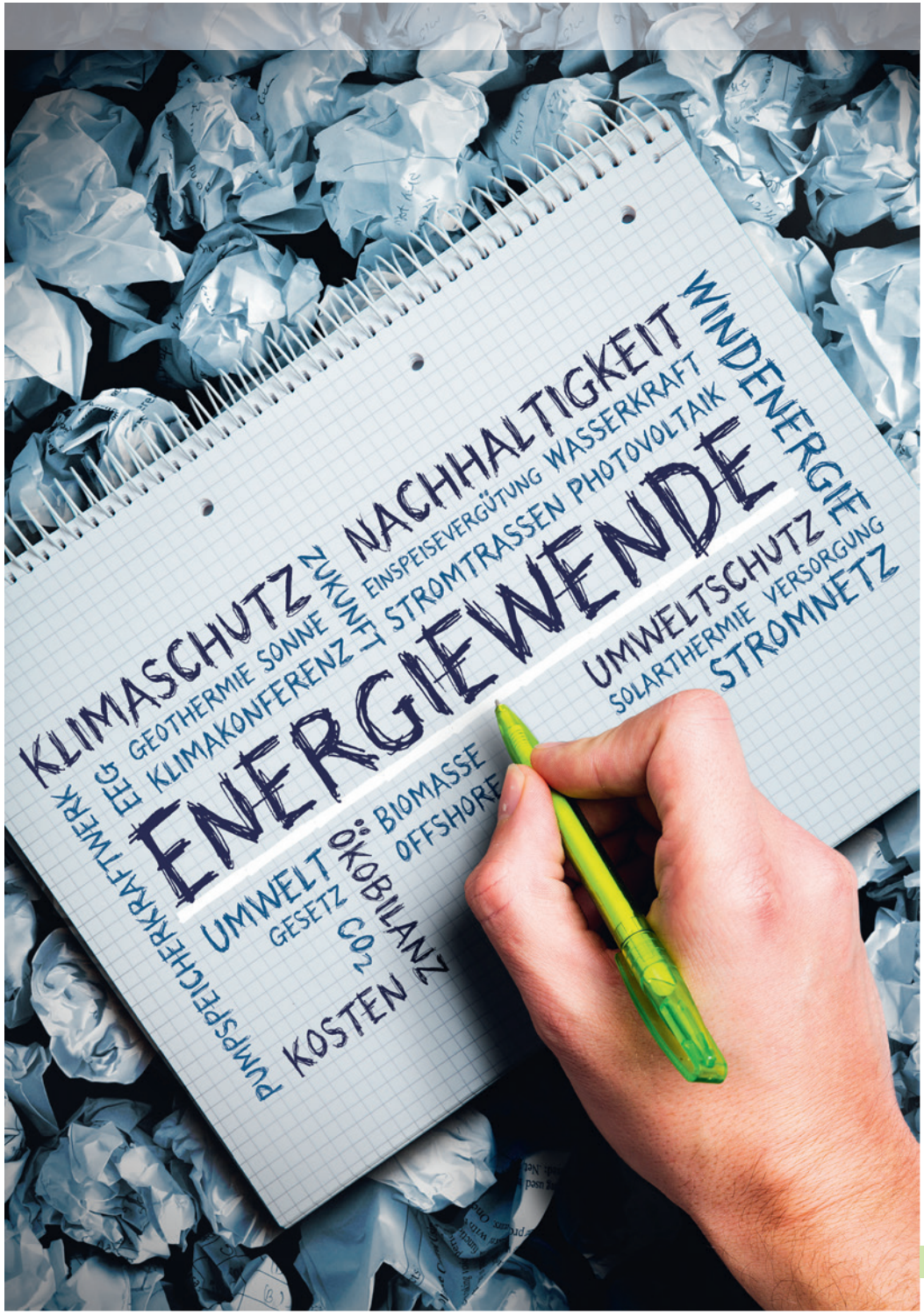

12 PROJECTS AND PUBLICATIONS

The most important projects and publications from 2016 are listed to show the current working areas of the DBFZ. The language of the title reflects the language of the project/publication.

PROJECTS (SELECTION)

Federal Ministry of Food and Agriculture (BMEL)

AG Biomassereststoffmonitoring, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.07.2016–30.06.2018 (FKZ: 22019215)

AquaMak – Aquatische Makrophyten – ökologisch und ökonomisch optimierte Nutzung – Teilvorhaben 3: Konservierung aquatischer Makrophyten zur ganzjährigen Nutzung für die anaerobe Vergärung, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.10.2014–30.09.2017 (FKZ: 22401914)

AUFWIND – Algenproduktion und Umwandlung in Flugzeugtreibstoffe: Wirtschaftlichkeit, Nachhaltigkeit, Demonstration; Teilvorhaben 3: Systemanalyse, Ökonomie und Ökologie – Technische und ökonomische Gesamtbewertung, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.06.2013–31.08.2016 (FKZ: 22408812)

BetEmBGA – Betriebsbedingte Emissionen an Biogasanlagen, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.02.2015–31.01.2018 (FKZ: 22020313)

Bioenergie-Regionen 2.0 – Technisch-ökonomische Begleitforschung "Bioenergie-Regionen 2.0", Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.03.2013–31.03.2016 (FKZ: 22020412)

BiogasFingerprint – Verbundvorhaben: Flexible Steuerung der Biogasproduktion mittels bioinformatischer Populationsanalyse, Teilvorhaben 2: Flexible Steuerung eines Pfropfenstromfermenters mit nachgeschaltetem Rührkesselfermenter, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.02.2015–31.01.2018 (FKZ: 22009114)

BioRexWiVe – Verbundvorhaben: Entwicklung und Demonstration eines bio-kraftstoffbetriebenen Range-Extender-Systems zur Reichweitenverlängerung elektrisch betriebener Nutzfahrzeuge im Wirtschaftsverkehr; Teilvorhaben 1: Biokraftstoffe, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.12.2016–31.05.2018 (FKZ: 22401315)

BKSQuote – Untersuchungen zur Ausgestaltung der Biokraftstoffgesetzgebung, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.06.2016–31.01.2018 (FKZ: 22401416)

BMPIII – Biogas-Messprogramm III: Faktoren für einen effizienten Betrieb von Biogasanlagen – Teilvorhaben 1: Energiebilanzierung, Flexibilisierung, Ökonomie, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.12.2015–30.11.2018 (FKZ: 22403515)

CARBOWERT – Einsatz der Hydrothermalen Carbonisierung (HTC) für die nachhaltige Behandlung und Verwertung von Fraktionen des Sanitärsektors im Sinne eines Biochar/Swechar-Konzeptes, Bundesministerium für Ernährung und Landwirtschaft/Bundesanstalt für Landwirtschaft und Ernährung, 01.10.2013–30.04.2017 (FKZ: 2815600211)

Diesel Kat Aging II – Verbundvorhaben: Schnelltest zur Alterungsnachstellung von Dieselabgaskatalysatoren im Betrieb mit Biokraftstoffen; Teilvorhaben 1, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V./Forschungsvereinigung Verbrennungskraftmaschinen (FVV) e. V., 01.10.2014–31.12.2017 (FKZ FNR: 22014514; FKZ FVV: 6011792)

EEBImSchV – Entwicklung von Empfehlungen zur Vorbereitung der wiederkehrenden Emissionsprüfungen nach 1. BImSchV, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.08.2015–31.07.2016 (FKZ: 22002015)

eMikroBGAA – Effiziente Mikro-Biogasaufbereitung; Teilvorhaben 2: Potenzialabschätzung und betriebswirtschaftliche Bewertung für MikroBGAA, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.11.2015–31.10.2017 (FKZ: 22401615)

Energieerzeugung aus aquatischen Biomassen am Beispiel der Co-Kultivierung von Wasserlinsen und Cyanobakterien; Teilvorhaben 2: Konservierung und Konversion der aquatischen Biomassen zu Biogas, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur

Nachwachsende Rohstoffe e. V., 01.08.2014–31.07.2017 (FKZ: 22401514)

HoPeS – Untersuchung und Screening erweiterter Qualitätsparameter zur Verbesserung der emissionsrelevanten Holzpelletqualität in der Praxis, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.03.2015–29.02.2016 (FKZ: 22017914)

Isotop Biogas – Überwachung von Biogasanlagen mittels der Analyse von Verhältnissen stabiler Isotope; Teilvorhaben 3: Referenzversuche zur Verifizierung des Isotopenuntersuchungskonzeptes und Entwicklung einer Zustandsklassifizierung, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.09.2014–31.08.2017 (FKZ: 22013113)

Klein aber effizient – Kosten- und energieeffiziente Biomethanproduktion (ERANET Bioenergy – SE.Biomethane), Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.02.2013–30.04.2016 (FKZ: 22028412)

KOMBIOPT – Energiemanagementsystem zur kombinierten Nutzung erneuerbarer Energien, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.02.2015–31.07.2017 (FKZ: 22403113)

LemnaGas – Energieerzeugung aus aquatischen Biomassen am Beispiel der Co-Kultivierung von Wasserlinsen und Cyanobakterien; Teilvorhaben 2: Konservierung und Konversion der aquatischen Biomassen zu Biogas, Bundesministerium für Ernährung und Landwirtschaft, Fachagentur Nachwachsende Rohstoffe e. V., 01.08.2014–31.07.2017 (FKZ: 22401514)

MetHarmo – ERA-NET Bioenergy: Europäische Harmonisierung der Methoden zur Quantifizierung von Methanemissionen aus Biogasanlagen, ERANET/Fachagentur Nachwachsende Rohstoffe e. V., 01.03.2016–28.02.2018 (FKZ: 22403215)

MPell – Kleinpellets – Grundlegende Voruntersuchungen zum Einsatz kleiner Holzpellets in Pelletöfen zur Emissionsminderung, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.08.2016–31.07.2017 (FKZ: 22404615)

Pfl-Mix – Spurenelemente durch Energiepflanzen – Stoffströme und Handlungsempfehlungen für eine optimierte Prozessbiologie in Biogasanlagen, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.12.2014–30.11.2017 (FKZ: 22019114)

REFAWOOD – ERA-NET Bioenergy: Ressourceneffiziente Brennstoffadditive zur Verringerung der verbrennungstechnischen Probleme bei der Rest- und Gebrauchtholzverbrennung, ERANET/Fachagentur Nachwachsende Rohstoffe e. V., 01.04.2016–31.03.2019 (FKZ: 22404215)

Repowering BGA – Potenziale zur Steigerung der Leistungsfähigkeit von Biogasanlagen – Energetische Effizienz von Repoweringmaßnahmen, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.01.2014–30.04.2016 (FKZ: 22400912)

QualiS – Verbundvorhaben: Brennstoff-Qualifizierung und Qualitätsmanagement in der Hackschnitzelproduktion; Teilvorhaben 3: Marktanalyse und experimentelle Unterstützung, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.06.2015–30.11.2016 (FKZ: 22035814)

SenSTEF – Sensorgestützte Verbrennungsluftregelung zur Minimierung der Emissionen von Biomasseheizkesseln, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.05.2015–31.05.2017 (FKZ: 22037314)

SubEval – Verbundvorhaben: Bewertung von Substraten hinsichtlich des Gasertrags – vom Labor zur großtechnischen Anlage; Teilvorhaben 1: Durchführung der Labor- und Praxisversuche, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 01.10.2015–30.09.2018 (FKZ: 22034614)

(Vor-)Studie zur Entwicklung eines Ausschreibungsdesigns für Biomasse im Rahmen des EEG 2017, Bundesministerium für Ernährung und Landwirtschaft/Fachagentur Nachwachsende Rohstoffe e. V., 11.08.2015–31.01.2016

Federal Ministry for Education and Research (BMBF)

BBCHEM – Aufwertung von kohlehydrathaltigen Stoffströmen zu bio-basierten Chemikalien. Teilvorhaben 2: Hydrothermale Umsetzung, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.03.2016–28.02.2018 (FKZ: 033RK031B)

BEPASO – Bioökonomie 2050: Potenziale, Zielkonflikte, Lösungsstrategien, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.12.2016–30.11.2019 (FKZ: 031B0232B)

BiogasFaserPlus – Spitzencluster BioEconomy: Energetische Nutzung und Optimierung im Gesamtzusammenhang der Kaskadennutzung, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.03.2015–31.08.2016 (FKZ: 031A443A)

BIONET – Int. Ausschreibung zur Ausarbeitung und Einreichung von 3 EU-Anträgen zum thema BioE und BioÖk, Bundesministerium für Bildung und Forschung/Deutsches Zentrum für Luft- und Raumfahrt, 01.07.2016–30.06.2018 (FKZ: 01DS16030)

BIOSOL – ERA-NET MED: Entwicklung und Demonstration eines hybriden CSP-Biomassevergaser Systems, ERA-NET MED/Bundesministerium für Bildung und Forschung/Deutsches Zentrum für Luft- und Raumfahrt, 01.10.2016–30.09.2019 (FKZ: 01DH16006A)

BioXfrac – Dezentrale Biomassekonversion durch Kombination innovativer thermomechanischer und biochemischer Technologien zur Gewinnung von fermentierbaren Zuckern und BioEnergie, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.03.2015–31.08.2016 (FKZ: 031A438C)

CapAcidy – IBÖ-02: Bio-basierte Carbonsäuren für die chemische Industrie aus anaerober Fermentation, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.03.–30.11.2016 (FKZ: 031B0138)

FEBio@H2O – Verbundvorhaben: Flüssige Energieträger aus einer integrierten hydrothermalen Umwandlung von Biomasse, Teilprojekt “Biomasseabbau und Gesamtprozess”, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.01.2013–31.10.2016 (FKZ: 03EK3508A)

HTCuPH – Spitzencluster BioEconomy: TG 4, Bioraffinerie zur integrierten hydrothermalen Produktion von Brennstoff sowie der Grundchemikalien Phenol und Furan aus Biomasse, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.11.2014–30.09.2017 (FKZ: 031A445A)

HYBE – ERA-NET MED: Entwicklung einer innovativen Hybridanlage für erneuerbare Energien basierend auf einer Kombination von Biomasse und Solarenergie und Entwicklung von fundierten Kenntnissen als Voraussetzung zur Anwendung in Ägypten und Marokko, ERA-NET MED/Bundesministerium für Bildung und Forschung/Deutsches Zentrum für Luft- und Raumfahrt, 01.10.2016–30.09.2018 (FKZ: 01DH16005C)

Ideenwerkstatt – Neue Produkte für die Bioökonomie: Bioeconomy meets Circular Economy – Rest- und Abfallstoffe für die bio-basierten Produkte von morgen, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.05.–31.08.2016 (FKZ: 031B183)

KomBiChem^{PRO} – Demonstrationsvorhaben: Fein- und Plattformchemikalien aus Holz durch kombinierte chemisch-biologische Prozesse – Teilvorhaben B, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 15.11.2015–14.05.2018 (FKZ: 031B0083B)

MaiD – Entwicklung eines Verfahrens zur Maisspindelernte sowie Erzeugung eines auf Naturmaterial basierenden Einblasdämmstoffes, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.09.2016–31.05.2017 (FKZ: 031B0258)

MKMeiler – Entwicklung eines ausgereiften Mehrkammerbiomeilers zur professionellen Wärmeerzeugung und Kompostgewinnung, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.09.2016–31.05.2017 (FKZ: 031B0244)

NEUWERT – stadtPARTHEland, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.09.2014–31.08.2019 (FKZ: 033L119E)

PhotoBioSense – Dual getriebener photonischer Sensor zur Überwachung von Biogasanlagen – Teilvorhaben: Validierung des Demonstrators, Bundesministerium für Bildung und Forschung/VDI Technologiezentrum GmbH, 01.01.2016–31.12.2018 (FKZ: 13N13827)

Spitzencluster BioEconomy – TG 5, Begleitforschung: Nachhaltige wettbewerbsstrategische Handlungskonzepte und Steuerungsinstrumente des BioEconomy-Cluster in Mitteldeutschland, TP 5.1.1, Bundesministerium für Bildung und Forschung/Projektträger Jülich, 01.07.2012–30.06.2017 (FKZ: 031A078B)

TREC-Donau II – Transnational Renewable Energy Cluster – Donau; Thematische Fokussierung Bioenergie, Koordination, Bundesministerium für Bildung und Forschung/Deutsches Zentrum für Luft- und Raumfahrt, 01.09.2016–31.08.2017

Federal Ministry of Transport and digital Infrastructure (BMVI)

DEMO-SPK – Forschungs- und Demonstrationsvorhaben: Einsatz von erneuerbarem Kerosin am Flughafen Leipzig/Halle, Bundesministerium für Verkehr und digitale Infrastruktur, Inhouse, 04.11.2016–30.04.2019

Machbarkeitsanalyse für eine PTG-HEFA-Hybridraffinerie in Deutschland, Bundesministerium für Verkehr und digitale Infrastruktur, Inhouse, 01.11.2015–31.10.2016

Federal Ministry for Economic Affairs and Energy (BMWi)/Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety (BMUB)

AdSynZIM – Entwicklung eines Gasreinigungskonzeptes zur Nutzung von Synthesegas aus der Biomassevergasung für die Herstellung von Methan, Bundesministerium für Wirtschaft und Energie/AiF, 01.07.2013–30.06.2016 (FKZ: KF2028007CL3)

AGRASIL – Herstellung hochwertiger poröser Silikate und Wassergläser durch kombinierte stoffliche und energetische Verwertung verschiedener SiO2-angereicherter Agrarreststoffe, Bundesministerium für Wirtschaft und Energie/AiF, 01.04.2015–31.03.2018 (FKZ: KF2028019ST4)

BalanceE – Synergien, Wechselwirkungen und Konkurrenzen beim Ausgleich fluktuierender erneuerbarer Energien im Stromsektor durch erneuerbare Optionen, Teilvorhaben: Bedarfsgerechte Bioenergie – Potenziale und Optionen, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.10.2014–30.09.2016 (FKZ: 0325705B)

Bioplan W – Systemlösungen Bioenergie im Wärmesektor im Kontext zukünftiger Entwicklungen, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.08.2016–31.03.2019 (FKZ: 03KB113A)

CLEANPELLET – Entwicklung eines Verfahrens für die Erzeugung emissionsarm verbrennbarer Gärrestpellets zur Nutzung als Brennstoff für Haus- und Kleinfeuerungsanlagen, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.09.2014–31.08.2017 (FKZ: 03KB099D)

Dampf-KWK – Entwicklung eines Klein-KWK-Dampfmotors zur Nachrüstung von Feuerungsanlagen im mittleren Leistungsbereich, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.07.2016–30.06.2019 (FKZ: 03KB118A)

ELEoE – Elektrisch leitfähige Emaillierung ohne Edelmetall, Bundesministerium für Wirtschaft und Energie/AiF, 01.03.2015–28.02.2017 (FKZ: KF2028018AG4)

ELIRAS – Entwicklung eines Leitfadens zur Auswahl von standortspezifisch angepassten Rühr- und Substrataufschlussverfahren für Biogasanlagen, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.01.2015–31.12.2017 (FKZ: 03KB106A)

EMOB – Flottenaufbau mit Multiplikatoren und wissenschaftlicher Begleitung – Multi-Flottenaufbau, VDI/VDE-IT, 01.12.2012–30.06.2016 (FKZ: 16SBS005B)

Entwicklung eines emissionsarmen Holzpellet Vergaserkessels mit einer kombinierten Scheitholznotfeuerung, Bundesministerium für Wirtschaft und Energie/AiF, 01.07.2014–01.02.2017

FermKomp – Abgestimmte Effizienzsteigerung und Emissionsminderung der Feststofffermentation mit nachfolgender Kompostierung, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.10.2014–30.09.2017 (FKZ: 03KB100A)

FlexiTorr – Flexibilisierung der Energiebereitstellung in Bioenergiekleinanlagen durch den Einsatz torrefizierter Brennstoffe, Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit/Projektträger Jülich, 01.09.2013–31.12.2016 (FKZ: 03KB091A)

Heißentwässerung – TKOR – HEPT/Thermo-Chemische Vorbehandlung, Edukt- und Filtermaterial-Definition, VDI/VDE IT, 01.07.2016–31.12.2017 (FKZ: 16KN058423)

HF-Technologie Abgas – Entwicklung einer innovativen Abgasnachbehandlungsanlage für Biomasse-Kleinfeuerungsanlagen unter Nutzung neuartiger Katalysatoren und dielektrischer Erwärmung, Bundesministerium für Wirtschaft und Energie/VDI/VDE IT, 01.07.2015–31.12.2017 (FKZ: 16KN041428)

HTK-Vergärung – Gewinnung von Biogas aus Hühnertrockenkot durch psychrophile Mono-Vergärung, Bundesministerium für Wirtschaft und Energie/AiF, 01.07.2015–30.06.2017 (FKZ: KF2028021SB4)

IbeKET – Innovatives bedarfsangepasstes Kommunal-Energieträger-Konzept, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 15.09.2013–31.01.2016 (FKZ: 03KB088D)

KoSePo – Kostensenkungspotenziale von Biogasanlagen im bestehenden EEG, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.11.2013–14.10.2016 (FKZ: 03MAP288A)

ManBio – Entwicklung von technischen Maßnahmen zur Verbesserung des Gasmanagements von Biogasanlagen, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.09.2014–28.02.2017 (FKZ: 03KB094A)

MiscPellTherm – Miscanthus-Mischpellet Brenner mit kleiner Wärmeleistung; Experimentelle Brennerentwicklung auf dem Prüfstand, Bundesministerium für Wirtschaft und Energie/AiF, 01.07.2014–30.06.2017 (FKZ: KF2028012ST4)

OptiMand – Optimierter Einsatz von Mühlennachprodukten zur bedarfsgerechten Energieproduktion durch innovative Überwachungs-, Mess- und Regelungsmethodik für die flexible Prozessführung, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 15.09.2016–14.03.2019 (FKZ: 03KB115A)

ProgBeg – Programmbegleitung für das Förderprogramm zur Optimierung der energetischen Biomassenutzung, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.01.2014–31.03.2017 (FKZ: 03KB001A)

ProgBegII – Programmbegleitung des BMWi-Förderprogramms “Energetische Biomassenutzung” – Ausbau des Wissenstransfers, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.07.2016–31.12.2019 (FKZ: 03KB001B)

RegioBalance – Bioenergie-Flexibilisierung als regionale Ausgleichsoption im deutschen Stromnetz, Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit/Projektträger Jülich, 01.08.2013–31.01.2016 (FKZ: 03KB087A)

SCR-Filter – Demonstration von Verfahren zur kombinierten Reduktion von Stickoxiden und Feinstaub aus Biomassefeuerungen, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.09.2014–31.12.2016 (FKZ: 03KB096A)

Spitzencluster BioEconomy – TG4, Entwicklung eines Demonstrators zur emissionsarmen Bereitstellung von Prozessenergie und Elektrizität aus Reststoffen der Bioökonomie, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.03.2015–30.09.2017 (FKZ: 031A598A)

STEP – Verwertung strohbasierter Energiepellets und Geflügelmist in Biogasanlagen mit wärmeautarker Gärrestveredlung; Teilvorhaben: Verbesserung der Verbrennungseigenschaften projektspezifischer Gärreste, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.08.2016–31.01.2019 (FKZ: 03KB116B)

stROhgas – Entwicklung eines Verfahrens zur Vergasung von asche- und chlorhaltiger Biomasse am Beispiel Stroh, Bundesministerium für Umwelt, Naturschutz, Bau und Reaktorsicherheit/Projektträger Jülich, 01.08.2013–30.04.2018 (FKZ: 03KB085B)

ToxOAb – Optimierung der Feinstaubminderung von Abscheidern für Biomassefeuerungen unter Berücksichtigung der toxikologischen Relevanz mittels mikrobieller Testsysteme, Bundesministerium für Wirtschaft und Energie/Projektträger Jülich, 01.09.2013–31.01.2017 (FKZ: 03KB090A)

XEFOK – Entwicklung eines neuartigen Adsorbers auf der Basis von Xerogelformkörpern und Einsatz zur Reinigung von biogenen Gasen, Bundesministerium für Wirtschaft und Energie/AiF-ZIM, 01.05.2014–30.04.2017 (FKZ: KF2028020ST4)

EU projects

BioEcoMatic – Construction of small-to-medium capacity boilers for clean an efficient combustion of biomass for heating, KIC Inno Energy, EU-Projekt, 05.04.2012–31.03.2016

Bioenergy4Business – Uptake of solid bioenergy in European commercial sectors (industry, trade,

agricultural and service sectors), EU-Projekt/Horizon2020, 01.01.2015–31.08.2017 (GA 646495)

BIOORC – Construction of cogeneration system with small to medium size biomass boilers, KIC InnoEnergy, EU-Projekt, 01.01.2015–31.03.2017 (FKZ: 13_2014_IP92_BioOrc)

BIOSURF – Unterstützung der Marktimplementierung von Biomethan, EU-Projekt/Horizon2020, 01.01.2015–31.12.2017 (GA 646533)

DEMETER – Demonstrating more efficient enzyme production to increase biogas yields, EU/Horizon2020, 01.08.2016–31.07.2019 (GA 720714)

GRAIL – Glycerol Biorefinery Approach for the Production of High Quality Products of Industrial Value, EU-Projekt, 01.11.2013–31.10.2017 (GA 613667)

RecordBiomap – Research Coordination for a Low-Cost Biomethane Production at Small and Medium Scale Applications, EU/Horizon2020, 01.04.2016–31.03.2018 (FKZ: GA 691611)

Service/Contract research

Abscheider – Qualifizierung eines Staubabscheiders mit Katalysator an Biomassekleinfeuerungen, IHK zu Leipzig, Wirtschaft trifft Wissenschaft, 01.05.–30.09.2016

ADIndia – Assessment of the status quo of the implementation and potentials of Anaerobic Digestion in India, Marktprojekt, 01.01.–31.12.2017

AirSoc01 – Katalysatortestung mit VGA, Air-Sonic GmbH, 02.08.2016–30.09.2016

AKUTDKTI – Unterstützung von AKUT/Rotaria do Brasil bei der Baselinestudie Biogas im Rahmen der DKTI Brasilien (AKUTBras), ARGE AKUT/Rotaria, 01.11.2015–31.10.2016

Algenkra – Evaluation des Potenzials von Algen als Biomasse für Biokraftstoffe der 3. Generation – Chancen und Grenzen, Deutscher Bundestag, 23.05.–30.08.2016 (FKZ: ZT6-1133-2016-132-15-PA18)

BioChem – Gärversuche mit Grünroggensilage, BioChem agrar GmbH, Marktprojekt, 15.07.2015–31.01.2016

CARIBREW – Supporting Institutional Structures to promote Renewable Energy and Energy Efficiency in the Caribbean Region, GIZ GmbH, 05.09.–17.11.2016

CoFire2 – Begutachtung von Biowärme aus Mitverbrennung von Biomasse in konventionellen Heizkraftwerken, Vattenfall Europe Wärme AG, 01.01.2014–31.08.2019

Consulting Services for Biogas Project Hebei, BZINE – Beijing Zhongshida Institute of New Energy Co., 01.08.2015–31.12.2019

Erstellung einer Benchmarking-Betrachtung: Sorghum vs. Maissilage zur Erzeugung und Bereitstellung von Biomethan, KWS Saat AG, 01.12.2012–30.06.2016

FBGAsens – FBGA Softsensor, Siemens AG, 21.07.2016–31.10.2016 (FKZ: 3210052)

IEA Bioenergy Task 37 Report IEA, Uni College Cork, Marktprojekt, 20.09.2016–31.12.2018

InnoFK – Innovationsforum FerroKat, DBI – Gastechnologisches Institut gGmbH, 14.10.2015–29.02.2016

JTIGRAS – Unutilized biomass for renewable energy- technique and environmental benefits, SP Technical Research Institute of Sweden, 01.10.2016–31.03.2018 (FKZ: 3250005)

JugoInsp – Inspection and support of the test institute JugoInspect in order to introduce EU-aligned testing services to wood fuel producers in Serbia, E4tech, 06.06.–31.10.2016 (FKZ: 3150005)

Kultursubstrate, IVG Service GmbH, 01.08.–30.09.2016 (FKZ: 3310045)

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MoKaTa – Katalysatortestung am BHKW Löberitz mit mobiler Katalysatortestanlage, Caterpillar Energy Solutions GmbH, 20.08.2015–31.03.2016

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