Deutsches Biomasseforschungszentrum
gemeinnützige GmbH

DBFZ

Annual Report 2021

Directions

By train: to Leipzig main station. Take tram line 3/3 E (towards Taucha/Sommerfeld) as far as the Bautzner Strasse stop. Cross the street, leave the car park on the right and use the main entrance of the DBFZ (House 1, Torgauer Str. 116). Please check in at the front office.

By car: on the A 14 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 3/3 E towards Taucha/Sommerfeld; Bautzner Strasse stop (see “By train” for further directions).

Deutsches Biomasseforschungszentrum
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DBFZ

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1 Editorial

Dear Readers,

The second year of the Corona pandemic has once again presented the DBFZ with special challenges. However, thanks to the hard work of a committed team, we were able to tackle these challenges well and can now look back on another busy research year that was filled with exciting projects and developments. We have included interesting information about this in our 2021 Annual Report.

We focused our personnel and technology on ways to use biogenic residues and waste for energy and materials. Research relating to the bioeconomy as a whole was further strengthened and we stepped up our international activities. Examples here are Prof. Dr. Daniela Thrän's co-chairmanship of the federal government's Bioeconomy Council and the appointment of Prof. Dr. Michael Nelles as the coordinator of Germany's activities in the International Solid Waste Association (ISWA) – the leading global network on all topics concerning the circular economy. One good example is the "ETH-Soil" project in Ethiopia which was launched in summer 2021. The € 18 million project has been commissioned by the BMZ and will run over the next five years.

In 2021, we were also able to advance our efforts regarding the important topic of "digitisation" at the DBFZ. An interview with the head of our newly established DataLab, Dr. Marco Selig, can be found on page 24.

One particular highlight was the very successful evaluation we received by the German Science Council, which found, among other things, that "since the previous evaluation in 2014, the Institute has developed into a renowned institution in the field of biomass research. Mention should not only be made of the quality of the DBFZ's scientific achievements, but also its excellent national and international networking with industry and the scientific community."

Fig. 1: The General Management of the DBFZ

As every year, we would like to take this opportunity to sincerely thank all our partners (Supervisory Board, Research Advisory Council, project management organisations and project partners) for their tireless input, many valuable suggestions and intensive cooperation!

Prof. Dr. Michael Nelles
Scientific
Managing Director

Ronny Bonzek
Administrative
Managing Director

2 Overview of the DBFZ

The DBFZ was founded on 28 February 2008 in Berlin as a non-profit, limited liability company in response to the complex issues relating to the provision and use of bioenergy. The sole shareholder is the Federal Republic of Germany, represented by the Federal Ministry of Food and Agriculture (BMEL).

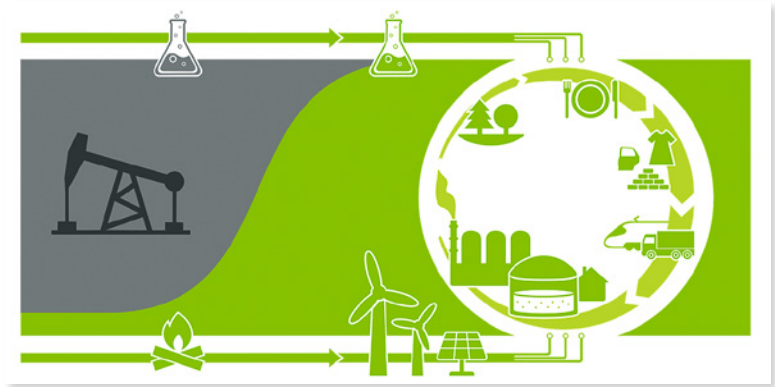
Fig. 2: The new DBFZ building (office and seminar building with adjoining technical centre), which opened in 2020

Vision

Our research is key to achieving a climate-neutral society by 2050 at which time the bioeconomy's closed carbon cycles will have replaced the fossil fuel-based economy.

Mission and Target Groups

- We conduct applied research and development.
- We investigate, develop and assess technologies for the integrated use of biogenic resources in energy and materials production.
- Our findings pave the way for the innovation of sustainable products and services already on the market to ensure a rapid transition to a climate-neutral society.
- We advise and prepare scientifically based information for the federal government.
- Our findings contribute to the development of rural areas, which are the points of departure for the bioeconomy.
- We are guided by the United Nation's Sustainable Development Goals (SDG)[1]
- Our research is directed towards stakeholders from science, politics, business and society with a focus on bioenergy, the bioeconomy and sustainable supply systems.
- We network with our partners in Germany and abroad, sharing our knowledge with them.



© DBFZ, 2020

Fig. 3: "Smart Bioenergy" in a sustainable bioeconomy

[1] https://sdgs.un.org/goals

Our Philosophy

- To fulfil our mission, we continue to develop our dedicated staff, our interdisciplinary expertise and our outstanding research infrastructure.
- As an independent federal research organisation committed to neutrality, we provide a scientific basis for decision-making and we design and initiate research strategies.
- We support young scientists by supervising their bachelor, master and doctoral dissertations.
- Our employees benefit from a broad training programme.
- We support our employees in the establishment of spinoffs and start-ups.
- We attach great importance to combining a career and family.
- In order to continuously improve our organisation, we regularly consult a research advisory council made up of international members as well as a cross-departmental supervisory board comprised of federal and state ministries.
- Our processes are constantly being optimised based on the ISO 9001 quality management system and the Guidelines for Safeguarding Good Research Practice.
- We strive to achieve climate-neutral operations by no later than 2030.

Download:
The DBFZ's Research, Development and Innovation Concept (As of November 2020)

27

Newly launched projects
(market and third-party funded projects)

265

Employees
as of 31/12/2021

196.500,– €

Average project volume
of the projects launched in 2021

55

Completed projects

61

Internal & external events
(online/hybrid/in person)

108

Processed projects

62

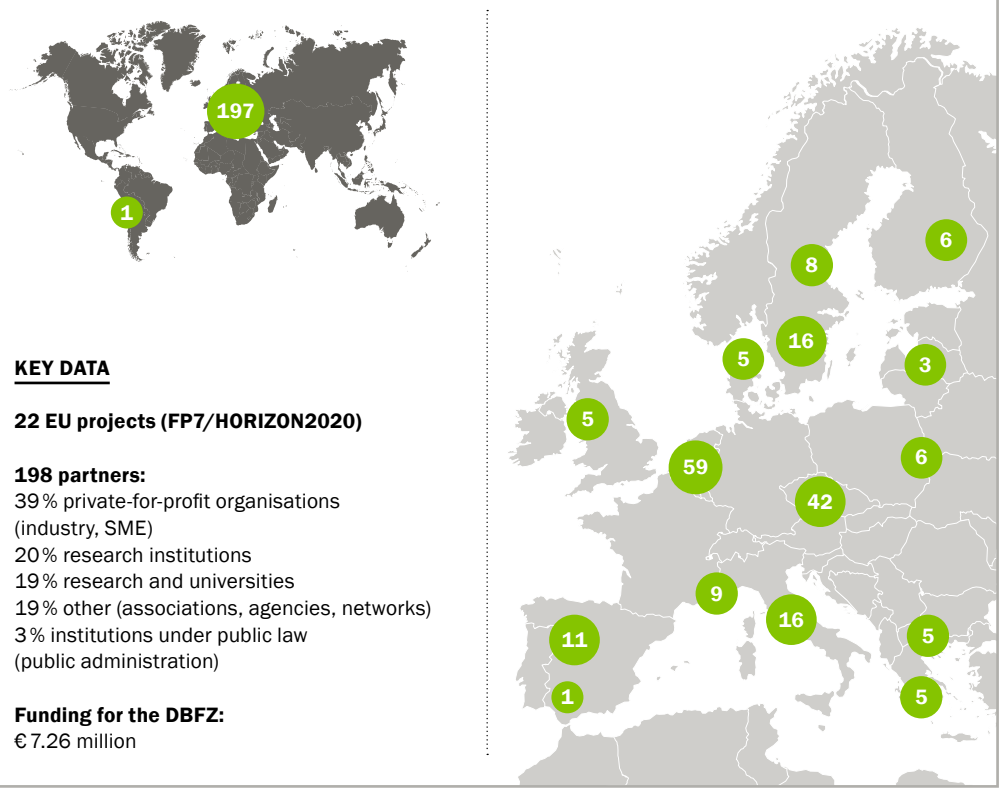
Peer-reviewed publications
(including 36 open access articles)

3 Key Figures and Scientific Highlights

Collaborative projects

Close research collaborations with numerous partners from science, industry and society has enabled the DBFZ to further consolidate its position in 2021 as the leading national research institution in the field of energetic and integrated material use of biomass. The DBFZ has also been continuously expanding its position on the international stage for more than ten years. For example, it is collaborating with nearly 200 partners in 22 EU projects and is an active member and national team leader of major international research networks such as the IEA Energy Technology Collaboration Programme, the European Energy Research Alliance (EERA) and the European Technology and Innovation Platform Bioenergy (ETIP Bioenergy). An overview of the DBFZ's extensive committee and network activities can be found in this Annual Report starting on page 110.

Main cooperation partners in the EU
(Number per country/region)



KEY DATA

22 EU projects (FP7/HORIZON2020)

198 partners:
39 % private-for-profit organisations (industry, SME)
20 % research institutions
19 % research and universities
19 % other (associations, agencies, networks)
3 % institutions under public law (public administration)

Funding for the DBFZ:
€ 7.26 million

Fig. 4: International cooperation at EU level

Publications

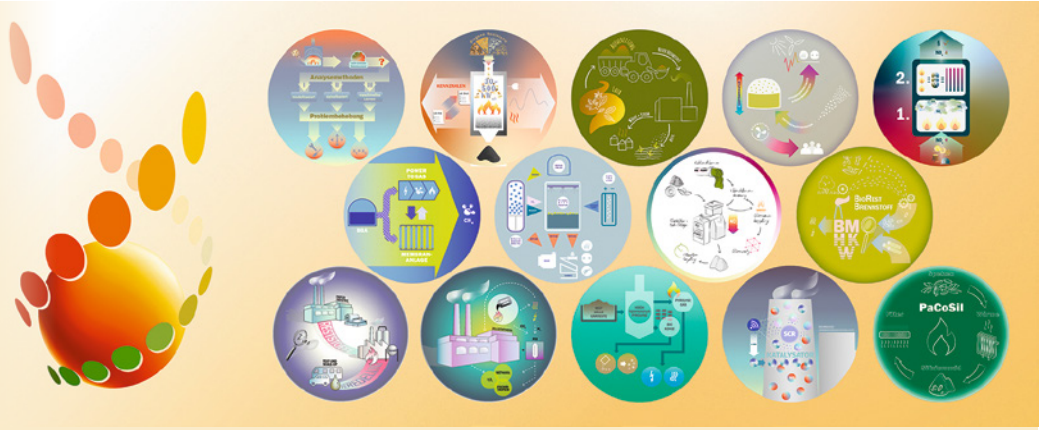
Every year the findings of collaborative projects are published in more than 60 peer-reviewed publications together with co-authors from 85 scientific, industrial and social institutions. The DBFZ contributes to more than 130 publications each year, including articles in technical journals as well as statements and position papers that provide information to interested practitioners and users. DBFZ scientists hold more than 150 lectures around the world, presenting the latest results and findings in bioenergy research, and network with the scientific community, practitioners and interested members of the public. An overview of the DBFZ's publications can be found in the Appendix starting on page 141.

→ **Further information:**
www.dbfz.de/en/press-media-library/publications-directory

Tab. 1: Publications between 2017 and 2021

PUBLICATIONS	2017	2018	2019	2020	2021
Book publications/editorships	19	12	9	12	15[2]
Book contributions	15	16	5	37	14
Journal articles (reviewed)	52	57	57	70	62[3]
Journal articles	16	14	10	11	11
Contributions to conference proceedings	47	35	44	27	31
Presentations	170	142	156	132	165
Research data	1	3	1	3	4
Total	**316**	**279**	**282**	**292**	**302**

[2] Eight monographs, two editorships of collected works, five editorships of conference proceedings
[3] Including 36 open access articles



BMWK bioenergy research program and network

The DBFZ has been hosting the scientific support project for the BMWK bioenergy research program since its inauguration in 2008. The program started off with a focus on biomass for energy generation in general, but was reclassified to "biomass from biogenic residues and waste for energy" in 2018 with the start of the new round of funding. In 2016 the associated research network bioenergy was added to the already established BMWK energy network and is now one of nine networks under the energy umbrella.

The scientific support project at DBFZ coordinates knowledge transfer activities as part of the research program. Although these activities are largely based on output from funded projects, the remit goes beyond this. This is evidenced in various publications as well as networking events such as workshops and the biannual bioenergy network conference in Leipzig.

In 2021, 15 new projects started as part of the bioenergy research program. Of these, DBFZ has been the project coordinator of five and involved in several others as project partner. The new projects address a variety of topics ranging from biogas and biomass gasification to system integration, combined heat and power solutions, and specific biomass combustion technology. In addition to technical research, projects address questions of market potential and concepts for biomass heating systems.

→ **Further information:**
www.forschungsnetzwerke-energie.de/home
www.forschungsnetzwerke-energie.de
www.forschungsnetzwerke-energie.de/bioenergy

Fig. 5: Video presentation as part of the German Science Council's evaluation process

Scientific Highlights

Successful evaluation by the German Science Council

After a year of preparation, the virtual visit and the renewed evaluation by the German Science Council was on the agenda on 13 and 14 April 2021. The aim of the evaluation is to modernise existing structures where necessary, strengthen competitive elements, increase the quality and efficiency of research, and contribute to improving the fulfilment of the tasks of the federal government. The evaluation was preceded by an intensive assessment and comprehensive evaluation report, numerous video interviews and meetings, as well as an inspection of the DBFZ. Due to the Corona pandemic, the evaluation in 2021 could only take place virtually and with pre-recorded videos on various research topics and the DBFZ's research infrastructure. In its final 80-page report for the evaluation period 2017–2019, issued in January 2022, the German Science Council again attested to the great progress made by the DBFZ and the important role it plays in addressing issues relating to the sustainable and efficient use of biomass and thus in promoting a more circular and biobased economic system in the future.

WR | WISSENSCHAFTSRAT

"The institute has developed into a renowned centre for biomass research. Not only does the quality of the DBFZ's scientific achievements deserve mention, but also its excellent national and international networking with industry and the scientific community."

The German Science Council, 2022

→ **The final statement of the German Science Council can be viewed under the following link:**
www.wissenschaftsrat.de/download/2022/9475-22.pdf (in German)

Memorandum of understanding in the area of biomass torrefaction

As part of a renewed research cooperation, representatives of the DBFZ and the Japanese Forestry and Forest Products Research Institute (FFPRI) reached an agreement virtually on 9 March 2021 to cooperate further in the area of biomass torrefaction. Japan is aiming for climate neutrality by 2050 and, in addition to hydrogen, is also focusing on expanding domestic biomass use. Both the DBFZ and the FFPRI are investigating electricity generation as well as heating applications in the lower voltage range with additional system-serving benefits. This plays an important role in Japan in connection with security of security of supply after earthquakes. Compared to untreated wood pellets, torrefied pellets can still be used after heavy rainfall.

Kick-off of the Ethiopia project “ETH-Soil”

The official launch of the “ETH-Soil” project for soil improvement in Ethiopia took place on 6 September 2021 in the presence of the Ethiopian Ambassador H. E. Mulu Solomon Bezuneh, representatives of the Saxon State Chancellery, and project managers from the DBFZ. The aim of the five-year project, which is being coordinated by the DBFZ, is to improve food security in three pilot areas in the Oromia region of Ethiopia through the use of biofertilisers from pyrolysis and biogas plants. Through this project, the DBFZ is expanding its existing portfolio of projects and measures in Africa and is making a significant contribution to bringing the technologies, skills and experience developed in Germany – and in Saxony in particular – to Ethiopia and, at some point, to Africa as a whole, for the benefit of the local people (see page 94).

→ **Further information:**
www.eth-soil.com

Fig. 6: Virtual MoU with representatives of the Japanese institute FFPRI (9 March 2021)

Fig. 7: Visit by the Ethiopian ambassador at the launch of the ETH-Soil project (6 September 2021)

Appointment of Professor Michael Nelles as ISWA coordinator

After two years of preparation, the German Association for Waste Management e. V. (DGAW) and the German RETech Partnership e. V. (RETech) decided to apply to become national members of the International Solid Waste Association (ISWA). The ISWA is the leading global network of experts in all practical and scientific issues relating to the implementation of a sustainable circular economy. The ISWA General Assembly unanimously approved the application at its meeting on 3 October 2021, with Germany becoming a national member under the coordination of Prof. Dr. Michael Nelles starting in January 2022. Professor Nelles holds the Chair of Waste and Material Flow Management at the Faculty of Agricultural and Environmental Sciences at the University of Rostock and is the scientific managing director of the DBFZ. As a board member of both associations, he will be responsible for coordinating the joint work as a national member as well as formally representing both organisations in the ISWA. The DGAW and RETech have been gold members of the ISWA since 2019 and are bundling their activities in a joint working group called “ISWA Germany”. Within the framework of the national membership, Germany’s activities will now also be coordinated through this working group.

DG AW RESSOURCEN NEU DENKEN.

German RETech Partnership
Recycling & Waste Management
Made in Germany

ISWA
International Solid Waste Association

→ **Further information:**
www.iswa.org
www.iswa-germany.de

Prizes and Awards

Fig. 8: Prof. Dr. Walter Stinner (front left) at the official presentation of the 2021 Biogas Innovation Award

DBFZ scientists receive the 2021 Biogas Innovation Award

DBFZ scientists won German Agriculture's Biogas Innovation Award yet again at the 14th Biogas Innovation Congress in 2021. For the first time, the science prize of € 10,000 was awarded to a joint Chinese-German project. Researchers Jianbin Guo and Hui Sun from the China Agricultural University in Beijing were recognised for their work on "Straw silage with liquid digestate – cost-efficient storage and processing for biogas production" alongside their German research partners Dr. Britt Schumacher and Prof. Dr. Walter Stinner from the DBFZ. The business prize went to Christoph Heitmann from BENAS Biopower GmbH for his work on "Magaverde – Magically Green Products". The awards ceremony took place in compliance with Corona hygiene regulations on the premises of the DBFZ, with the Chinese scientists joining in via video link. Prof. Dr. Walter Stinner accepted the award certificates on behalf of the recipients of the science prize.

Hossein Beidaghy Dizaji receives the 2021 EUBCE Student Award

DBFZ scientist and PhD student Hossein Beidaghy Dizaji (Thermo-chemical Conversion Department) received the Student Award at EUBCE 2021. As part of his doctorate at the DBFZ, Hossein Beidaghy Dizaji is researching key factors that influence the slagging behaviour of silicon-rich solid biomass fuels such as rice straw and husks so that the ash obtained from the combustion can be used as high-quality biogenic silica for material applications. More information about his research project can be found in this Annual Report starting on page 75. Two scientific articles by Hossein Beidaghy Dizaji, published in the journals "Applied Sciences" and "Fuel" in autumn 2021, were also rated as being a "highly cited paper" and the "most downloaded article".

Christoph Siol receives the 2021 Energy and Environment Foundation Award

DBFZ scientist Christoph Siol (Bioenergy Systems Department) has received the Energy and Environment Foundation's prize for his master's thesis "Evaluating the ecological effectiveness of a catalyst for reducing emissions from manually operated wood stoves using a life cycle assessment (LCA)". With this annual award in the category "Energy and Environment", the Leipzig Energy and Environment Foundation honours outstanding scientific papers that investigate environmentally friendly technologies for energy production and study the use of energy resources.

Fig. 9: Award winner Christoph Siol

Fig. 10: DBFZ scientist Karoline Fürst receiving the 2021 Bioeconomy Camp Award

Karoline Fürst receives the 2021 Bioeconomy Camp Award

The Federal Ministry of Education and Research (BMBF) and the University of Hohenheim brought together talented young scientists from universities, foundations and research institutions at the 2021 Bioeconomy Camp, the Year of Science research convention held between 30 September and 1 October. The aim of the virtual event was to promote cross-disciplinary networking in an innovative real-lab environment. DBFZ scientist Karoline Fürst (Bioenergy Systems Department) won the Bioeconomy Camp prize of € 3,000 for her submission "A showcase of the Bioeconomy in Central Germany and Lusatia". The artefact was created as part of the "MoreBio" project and is a small showcase displaying the bioeconomy in Central Germany and Lusatia. The research project "Model Regions Bioeconomy – MoReBio" at the DBFZ is accompanying the development of the bioeconomy in the coal regions of Central Germany.

4 Interview: Digitalisation in Research

The technical capabilities of automated data processing have changed rapidly in recent years. Digital data are becoming increasingly important as a result of and, at the same time, as a source of scientific excellence. The principle of “as open as possible, as closed as necessary” applies here. However, the quantity and diversity of the research data requires cross-departmental work structures as well as sufficient capacities for a sustainable and demand-oriented development of digital data products. The “DataLab” working group, which was set up in 2021, has established a “data warehouse” that continues to expand. It aims to develop and operate digital data products, interactively visualise complex data content, and implement an application-oriented “data science” across all research departments of the DBFZ.

An Interview with Dr. Marco Selig

Dr. Selig, you have been responsible for the "DataLab" at the DBFZ since 2021. Can you please explain what your mission is?

MARCO SELIG: My mission is to support the researchers at the DBFZ in their scientific work through a professional digital structure so that they can effortlessly use the latest methodologies in information technology and data science for the benefit of their research projects. The establishment of a data lab at the DBFZ is intended to create the necessary framework conditions for this. This includes systematic data storage, the development and continuous improvement of digital data structures, as well as the establishment, operation and maintenance of database systems, analysis routines and access options that span topics and projects. The goal must always be to make the research data available and sustainably usable in accordance with the FAIR principles.

Please explain to us what these FAIR principles are.

MARCO SELIG: FAIR is an English acronym and "FAIR data" are data that are findable, accessible, interoperable and re-usable. These principles are the basis for the re-use of data, including all digital data from a scientific project, in other words, qualitative and quantitative research data as well as metadata or algorithms, software and other tools. It should be mentioned that accessibility refers to technical implementation and is not synonymous with free access. Data that comply with the FAIR principles can be available to everyone because the FAIR principles allow access restrictions (e. g., for the protection of personal data). At the same time, data are considered FAIR if they are well documented and machine-readable, have an open licence, are listed in the appropriate repositories, and use manufacturer-independent formats and open standards.

"The challenge is to understand the different scientific methodologies in order to be able to make sense of the data."

In data management, the personnel structure often consists of data scientists, data curators, data engineers or full stack developers. That sounds more like IT than science, where do you place yourself?

MARCO SELIG: These, sometimes, flowery role descriptions are meant to clarify the main tasks of data management for people in the know. Just as a museum curator looks after historical exhibits, a data curator looks after the DBFZ's "treasure trove of data". The archaeologists of this "museum" are the data scientists who, instead of speaking ancient languages, fluently speak the programming language Python. For the sake of simplicity, however, I would say there are only "data scientists" at the DBFZ. In my view, the DataLab is a scientific working group that collaborates with the other researchers at the DBFZ on an equal footing. The fact that we can exchange ideas not only with the scientists but also with IT at a high professional level is equally beneficial for the projects and for everyone involved.

What are the specific challenges in linking scientific results with digital structures?

MARCO SELIG: The aim of research is to gain knowledge. The first challenge is to understand the different scientific methodologies in order to make sense of the data. Only then can the underlying information be structured appropriately in order to capture the insights that have been gained. In concrete terms, this means finding a common "language" with each project team so that the DataLab can optimally fulfil its task as an interface between biomass research and digitisation. Furthermore, it is important to offer these digital structures to third parties, such as scientific colleagues, stakeholders from politics or industry, and private individuals with a thirst for knowledge, in a way that meets their needs. This ensures that the knowledge that has been gained does not drain away, but can be taken on board and be of real benefit.

PROFILE

Dr. Marco Selig has been an enthusiastic probability theorist and data scientist since completing his doctorate in physics at Ludwig Maximilian University in Munich. He was able to professionally use his passion for software development and his leadership skills at the IBM Research & Development Lab in Böblingen and is now relaunching his scientific career as head of the DBFZ's DataLab.

How do scientists turn an idea into a digital data product and what does this look like?

MARCO SELIG: Ideally, researchers involve the DataLab at the idea stage so that a (sub-) work package "data product", which is also reflected in the data management plan, can al-

ready be defined in the application phase. Depending on the project, a "data product" can be data curation, data processing using statistical or artificial intelligence methods, or a database. Or it can be a database-, web- or mobile-based application, a machine-readable programming interface (application programming interface, API), an independent peer-reviewed publication of data or, of course, any combination of these and other options. A concrete example is our DataLab, a web portal with a selection of freely accessible research data from the field of the bioeconomy. (More can be found on this starting on page 32).

In your view, what factors are particularly important for actively shaping the digital transformation, especially in the field of research?

MARCO SELIG: The decisive factor is quite clearly to participate! Those who participate will increase their own data literacy and can thus influence political decisions or the strategies of project sponsors through projects and discussions (even if this is mostly only done indirectly). For example, the DBFZ is involved in the Horizon Europe work programme and in the BMEL's Digitisation Think Tank, where it is actively shaping the digital transformation.

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The federal government's data strategy focuses on the topic of "open data" as a driver for innovation. What role does open data play in research?

MARCO SELIG: Science is based on the perpetual battle between hypothesis and experiment. Making collected data open, i. e., freely accessible to all (subject to known restrictions based on data protection and legitimate interests etc.) is not only good scientific practice, but the only way to practice science. Disclosing data naturally supports one's own research findings. If this is done in accordance with the aforementioned FAIR principles, third parties can also use the data, both to critically review the results and to find answers to further questions. I am firmly convinced that open data can enormously increase the quality of research as a whole. Incidentally, this is also the view of the German Science Council, which is currently calling for open access publishing to be made an element of good scientific practice.

Is "open science" the research structure of the future?

MARCO SELIG: I come from the field of physics, where open access was practised even before it was called that (for example, on arXiv.org). In other words, for me, this open way of handling knowledge, be it data or publications, is already the normality today. The decisive factor here is the well-established scientific principle of peer review, i. e., peers (outside the project) check the content and ensure scientific quality by speaking with the authors.

How can "artificial intelligence" support a scientist's work?

MARCO SELIG: Scientists are already using artificial intelligence (AI) to create efficient experimental designs and to analyse all kinds

"Making collected data freely accessible to all is not only good scientific practice, but the only way to practice science".

of research data. In the field of computational linguistics, for example, AI has long been able to read scientific articles, create summaries, detect gaps in knowledge and even write essays, articles, patents or books. All of this is, of course, a question of the amount of resources invested and the quality of the data (both in terms of quantity and meaningfulness). In the end, the question is not so much whether artificial intelligence can be used, but whether this is currently worthwhile. Therefore, no researcher needs to fear losing his or her job. Instead, advances in AI technology and the possibilities it offers should be seen as an opportunity to significantly expand one's own toolbox.

Under what conditions can artificial intelligence really lead to sustainable innovation and value creation?

MARCO SELIG: Unfortunately, there is still no universal AI that can solve all of our problems once it has been switched on. It is more the case that highly specialised forms of AI will help us deal with specific issues. This assumes that the issues are approached in a scientific way and that AI methods are applied and refined. It therefore requires the courage to face the problems that cannot be solved by humans (and occasionally to fail), but also the staying power to bring the resulting solutions to product maturity – if necessary, over a longer period of time.

From the data expert's point of view: where does the national research landscape stand on the topic of digitisation?

MARCO SELIG: The level of digitisation in Germany varies greatly depending on the subject area and type of institution. Overall, I feel a strong tailwind at the moment – from legal reforms around OpenData, the massive funding to build and expand the national research data infrastructure, and the digital mindset across all management levels – so I am positive that we will catch up quickly at the national level. We can now build upon the groundwork so that issues such as data protection, explainability of models, and ethical principles can be anchored in our digital future right from the start.

Thank you for the interview.

→ **The DBFZ's DataLab**
https://datalab.dbfz.de/home/?lang=en

5 Research Focus Areas: Reference Projects

A large number of different research projects on the use of biomass for energy and as an integrated material were successfully completed in 2021. Major research topics are divided into five research focus areas. They ensure that important aspects of bioenergy and the bioeconomy can be covered at the depth necessary to provide excellent research. The DBFZ's research focus areas are oriented towards current and future research policy challenges and framework conditions (e.g., the national research strategy BioEconomy 2030, the national policy strategy BioEconomy, the Mobility and Fuel Strategy, and the Biorefineries Roadmap). Important aspects for the scientific orientation of the research focus areas are the funding policy framework, the unique selling point within the research landscape, and the DBFZ's excellent infrastructure.

→ **Further information:**
www.dbfz.de/en/research/research-focus-areas

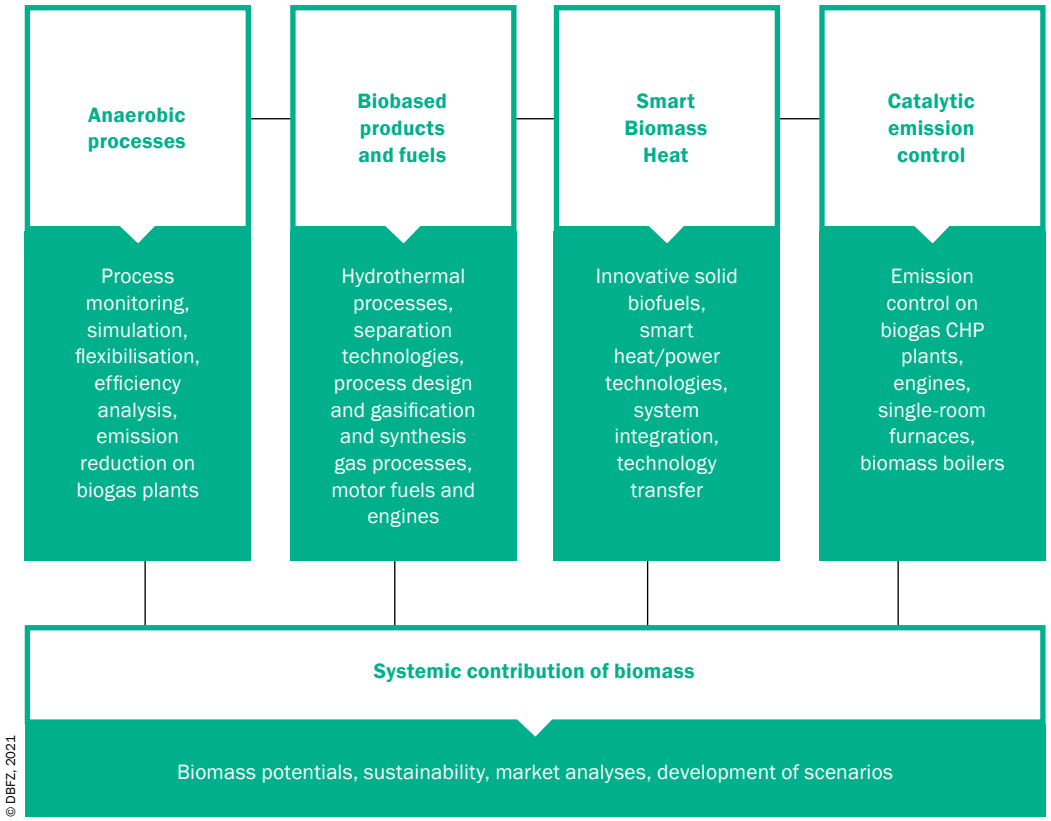

Fig. 11: The five research focus areas of the DBFZ

5.1 Dashboards for “Regional Biomass Potentials”

“The DBFZ’s new raw material dashboards allow anyone who is interested to study the temporal development and spatial distribution of various biogenic residues and waste materials for Germany. To ensure that the underlying research results can be used as extensively as possible, all data are available in a scientific and referenced data publication that can be downloaded free of charge.”

Jasmin Kalcher
Project Leader

Dashboards for “Regional Biomass Potentials”

The reduction of greenhouse gases is at the top of the agenda of many political and corporate strategies. Efficient use of resources plays an important role in achieving climate protection goals. Biogenic residues and waste materials represent a particularly large and often untapped potential that should be utilised more and more. Therefore, in addition to the question of “HOW MUCH?”, it is crucial to ask “WHERE?”, because raw materials, production sites, infrastructures and ideas are often spatially separated from one another. To help answer this question, the DBFZ developed three interactive dashboards that present information on the biomass potential in Germany for initially seven types of biomass (cereal straw for fermentation, sewage sludge from municipal sewage treatment plants, biowaste from the compost bin, garden and park waste, cattle slurry, cattle manure and solid cattle dung). The dashboards allow users to select the different types of biomass, reference years, key information (potential levels) and units. All data can be displayed either at the state or district level and can be downloaded and used free of charge (licence for use: CC BY 4.0). For dashboard users who are interested in specific regions, the web applications also offer the possibility of selecting specific states or districts and combining them freely. Users not only receive a map of what they individually selected, but also further information on the selected region. This includes:

- Ranges (min/max values), which, for example, show how uncertain the basis of the data being used is,
- a ranking of the selected regions according to the level of the respective biomass potential,
- a time series providing information on the development of the biomass potential for the period 2010 to 2018.

The selection window, map and associated interactive elements are displayed on the same screen so that the user can obtain a quick, intuitive overview of the information. The interactive section is supplemented by a range

KEYWORDS

Biomass potentials
raw material base
digitisation
OpenData
WebApp

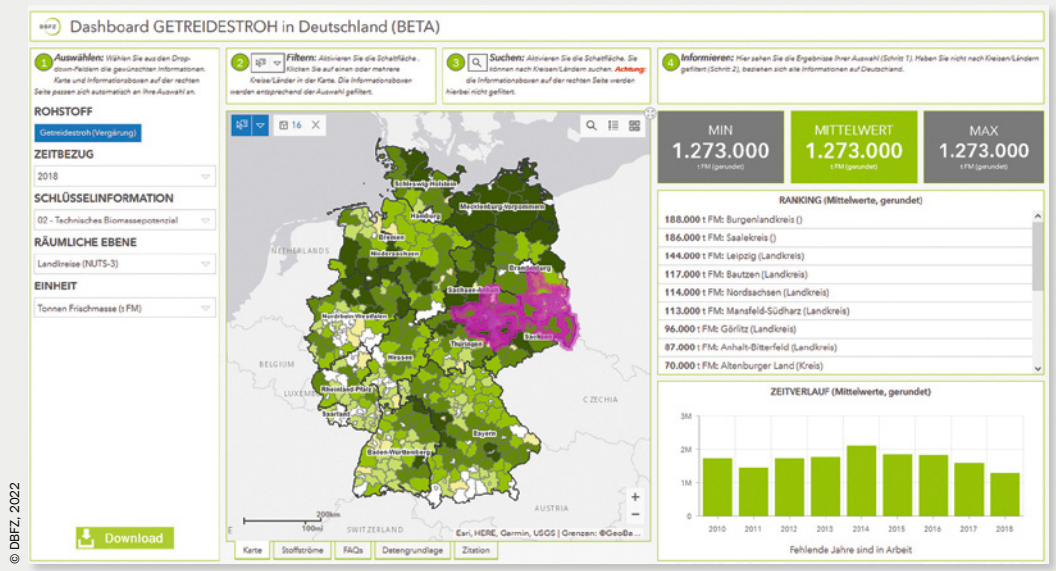

Fig. 12: Dashboard with the technical biomass potential of cereal straw based on selected regions (focus on the regions “Lusatian and Central German coalfields” as part of the MoreBio project)

of additional information. Background information is separated into the tabs “Material Flows”, “FAQs”, “Data Basis” and “Citation” to help interpret the results and illustrate the dashboards’ range of functionality. Figure 12 shows the dashboard with the technical biomass potential of cereal straw based on selected regions.

The dashboards serve as a low-threshold point of contact for various target groups. The maps enable key statements to be quickly made (e. g., “highly mobilisable biomass potential of cereal straw fermentation available in Mecklenburg-Western Pomerania”). At the same time, further information (e. g., “How was the data calculated?”) allows for a deeper dive, if required. In this way

_ policymakers can estimate the biomass availability in Germany or in the regions they select;
_ scientists can download the data and use it in further analyses;
_ business representatives can determine how high the biomass potential is around an existing or planned plant location.

Methods/Implementation

The approach used to create the dashboards can be divided into two main blocks:

Calculation of biomass potentials and creation of supporting material: The results of various research projects in which the biomass potential of various residual and waste materials was determined flow into the web applications described above. The calculations of the biomass potentials are primarily based on official statistics provided by the federal government and the federal states, as well as various other calculation elements (including conversion factors) that were collected or compiled as part of the monitoring of national residual materials [1]. A major part of the work involved harmonising the formats and units of the source data and calculating or modelling the biomass potentials for the missing years. The harmonised data were then transferred to a geodatabase using an automated workflow on which the dashboards are ultimately based.

To facilitate the comparability of the different types of biomass with each other and with other potential studies [2], the underlying data and methods were transparently documented and described with metadata records. All results can be downloaded free of charge in a scientific and referenced data publication [3].

Technical implementation: Before a comprehensible and intuitive web application could be developed, a conceptual design of the web application was created (“wireframe”). This roughly defined the content, functions and structure of what would later be the user interface (e. g., placement and size of the text, logo, selection menus, map/map elements). In the second step, the conceptual design was refined into a visual design (“mock-up”) that depicted the design of the subsequent web map (e. g., colour scheme of the symbolisation, symbols and logos). Agile software development methods were used to create the designs and the prototype. An iterative approach was used to create the conceptual and visual designs and the following steps were repeated until the specified requirements were met:

1. Creation of the design
2. Assessment of whether the design meets the requirements. This was done through tests and by surveying an internal DBFZ user group.
3. Implementation of improvements.

“ArcGIS Dashboards” was used to technically implement the web applications. The advantage of this form of presentation is that many

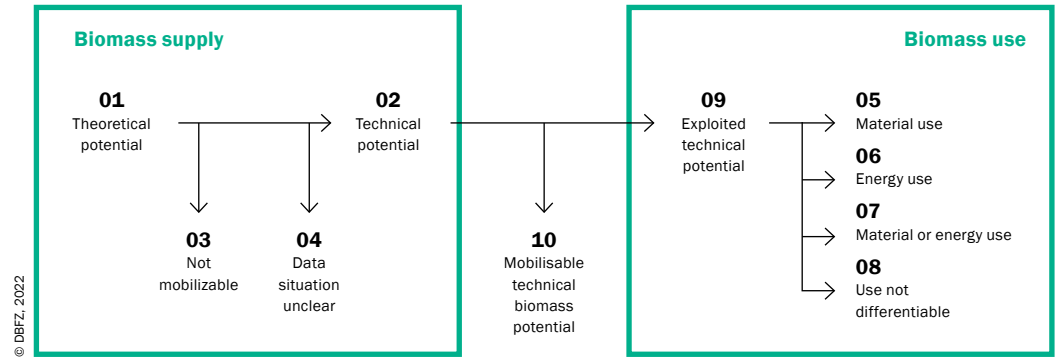

Fig. 13: Diagram of the material flow of a specific biomass with a total of 10 key pieces of information that consistently describe the potential and current use of the biomass (based on [4])

users are already familiar with it from the “Corona Dashboards” of the Robert Koch Institute (RKI) and John Hopkins University.

Milestones/Challenges

The beta version of the dashboard and the publication of the associated data were released in October 2021. The integrated visualisation of data, such as the time series or ranking by district, proved to be a valuable innovation over previous, purely interactive or static maps. These help interpret the map, address new target groups, and provide the basis for further research questions. As described above, various steps were necessary to reach these milestones. Their establishment also makes an important contribution to the future development of similar products, for example, the development of a workflow for the harmonisation of different geographical input data and the storage of datasets in a geodatabase.

However, the calculation and visualisation of regional biomass potentials also pose various challenges. For example, to date there is no recognised standard for calculating biomass potentials. This problem is being addressed at the DBFZ by describing input data and calculation methods as transparently as possible [4]. This makes it easier to compare different forms of biomass with each other, and any deviating results of other potential studies can be explained more easily. In the project described above, various “accompanying documents” (in particular DBFZ flowcharts) were therefore also adapted to regional issues. The DBFZ flowcharts visualise the calculation methodology for the individual forms of biomass, list the input data used, and, at the same time, assess their quality.

Different reference units for the initial data posed another challenge. For example, the biomass potential for “sewage sludge” can only be given in tonnes of dry mass (t DM), as the corresponding statistics do not record fresh mass. The web application also faced obstacles when it came to combining several years to show the development in the different regions over time. For example, territorial reforms in which the name and territorial status (e. g., of a district) are changed must be methodologically and technically taken into account. One example of this are the district reforms in Mecklenburg-Western Pomerania in 2011, in which district boundaries were redrawn and districts renamed. Methods of spa-

tial disaggregation were applied in order to be able to compare the year 2010 (old territorial status) with later years (new territorial status).

The challenges described above could partly be solved during the development of the dashboards or are being addressed in various current and planned research projects (see section on “Outlook”).

Outlook

The aim is to expand the results published so far to include further types of biomass, key information (e.g. mobilisable technical biomass potential) and geographical areas. Thus, the methods for calculating biomass potentials are constantly being developed and adapted to new scientific findings. In 2022, for example, the methodology for calculating cereal straw potential (fermentation) will be revised in the Pilot-SBG project, and the potential for various agricultural residues will be determined in the NUTS 3 regions of the EU-27 within the framework of the EU CAFIPLA project.

However, the current technical design only allows the layout and functional scope to be adapted to a limited degree, and expanding the database is time-consuming. Furthermore, the loading time (performance) of the web application is not ideal for the envisaged data volumes. In collaboration with the DBFZ’s DataLab, an internal solution is therefore being developed to replace the current dashboards with a product developed at the DBFZ (release planned for late 2022/early 2023). This will be another important step towards digitisation and data provision, which will also facilitate the increased integration of application programming interfaces (API) for the (partially) automated calculation of biomass potentials in the future. The existing dashboards provide an important basis for this internal development, including the implementation of a target group-oriented design and the establishment of workflows for data processing.

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PROJECT PROFILE

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1/1/2021–30/9/2021

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Dr. Friederike Naegeli de Torres

Funding bodies:
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The input data and methods used originate from various research projects:
AGBioRestMon (FKZ 22019215);
Pilot-SBG (funded by BMVI);
MoreBio (funded by BMEL/FNR);
BEniVer (FKZ 03EIV116C);
PEGGÜ (funded by BMEL);
OpenGeoEdu (FKZ 19S2007D).

DataLab

→ **Further information:**
https://datalab.dbfz.de/home/?lang=en (OpenData platform)
https://doi.org/10.48480/95ct-gn40 (Data published on OpenAgrar)

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The Research Focus Area “Systemic Contribution of Biomass”

The research focus area contributes to the development of sustainable bioenergy strategies at a national and international level. Here, regionally and globally available biomass potentials are determined and various biomass utilisation concepts are considered and evaluated. The overarching goal is to solve methodological and system engineering issues surrounding the efficiency and sustainability of biomass use from an economic, ecological and technical perspective, taking into account both the land resources used and the energy carrier-specific processing and conversion technologies. The combination of these aspects provides the basis for deriving strategies and recommended courses of action for policymakers and corporate decision-makers.

Important reference projects and publications

Project: BeForce – Accompanying Research on Bioenergy, Federal Ministry for Economic Affairs and Energy, 1/4/2021–31/3/2025 (FKZ: 03EI5400)

Project: BIOKRAFT – Raw material availability of woody biomass for the production of biofuels in DE and EU until 2040 (BIOKRAFT), Federal Ministry of Transport and Digital Infrastructure, 1/1/2020–31/8/2022

Project: BRANCHES – Boosting Rural Bioeconomy Networks following multi-actor approaches, European Commission, 1/1/2021–31/12/2023 (FKZ: GA 101000375)

Project: SoBio – Scenarios of optimal energetic biomass use by 2030 (under the RED II) and by 2050, Federal Ministry of Food and Agriculture, 1/1/2020–31/12/2021

Project: ZertGas – Implementation of the RED II and development of practicable certification solutions and courses of action for operators of biogas and biomethane plants, 1/9/2019–31/12/2021 (FKZ: 03KB164)

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5.2 Research Project “Junior Research Group”

“The junior research group implements and evaluates suitable methods for model-based process monitoring and control, and develops these so that they can be directly applied in the control systems of industrial anaerobic digestion plants. The interdisciplinary research project thereby creates the fundamental requirements for establishing model-based automation concepts for the long-term monitoring and control of regular plant operation.”

Dr. Sören Weinrich
Project Leader

Junior research group for the model-based monitoring and control of anaerobic digestion plants

With more than 8,600 industrial anaerobic digestion plants, biogas technology is making a significant contribution to the supply of sustainable energy in Germany. However, as the original EEG remuneration expires, the question of economic viability arises for many operators. Current funding conditions are deliberately leading to a considerable decline in the construction of new plants and are directing the use of biogas technology towards decentralized and flexible power generation from biogenic waste materials. The ongoing social and political discussion clearly shows that a lasting acceptance for the expansion of the German biogas technology is only possible if the biochemical potentials of the utilised substrates as well as the characteristic advantages of their use as energy or materials in anaerobic digestion plants are taken into account.

KEYWORDS

Anaerobic processes
biogas technology
process modelling
condition monitoring
control
machine learning
laboratory and practical trials

Current research projects examine numerous process and operating concepts in order to integrate anaerobic digestion plants into the future energy system and into sustainable material cycles [1]. Thus, biogas plants can be used to provide biomethane on demand or as a carbon source for the production of basic chemicals. In this context, all plant concepts depend on precise process control, taking into account important influencing factors and biochemical limits, in order to enable flexible but safe plant operation at all times (including strongly fluctuating substrate qualities or quantities).

Combined with the available sensor data and laboratory analyses, the application of rigorous process models provides valuable information for the automated, efficient and secure operation of anaerobic digestion plants [2]. However, due to complex model structures with a multitude of unknown model parameters and input variables, model-based automation concepts cannot yet be used in regular plant operation. There is still a need for in-depth investigations into the implementation of model-based simulation and control procedures for the dynamic monitoring and process control of industrial anaerobic digestion plants. As a result, little is known about the specific possibilities and limitations of model-based automation concepts for full-scale operation.

The junior research group is implementing and evaluating suitable methods for model-based process monitoring and control and developing these so that they can be directly applied in the control systems of industrial anaerobic digestion plants. The interdisciplinary research project thereby creates the fundamental requirements for establishing model-based automation concepts for the long-term monitoring and control of regular plant operation.

Methods/Activities

As part of basic application-oriented research, the comprehensive methodological spectrum of available model theories – from simplified material and mass balances and practice-related reaction models to complex model approaches of the established Anaerobic Digestion Model No. 1 (ADM1) – is to be examined in detail with regard to a uniform and transparent structure for system analysis and model development. Due to numerous influencing factors and measurement uncertainties at full-scale operation, actual process behaviour usually cannot be described in detail (even with complex process models based on established model equations). For realistic simulation results, suitable reaction models need to be supplemented by stochastic methods based on artificial intelligence or machine learning. Thus, hybrid modelling enables known information and functional relationships from established process models to be used and the remaining model deviation can be explained or deduced based on empirical relationships (for example, through an artificial neural network).

For the development of practical automation concepts, model-based monitoring and control procedures need to be evaluated with regard to the specific requirements of the measurement and control technologies available at full-scale biogas plants. System analysis of observability and identifiability enable a detailed and reliable evaluation of available process models and balances for robust application in industrial control systems. In order to continuously improve the model, characteristic procedures for optimal experimental design (OED) are to be applied to enable clear

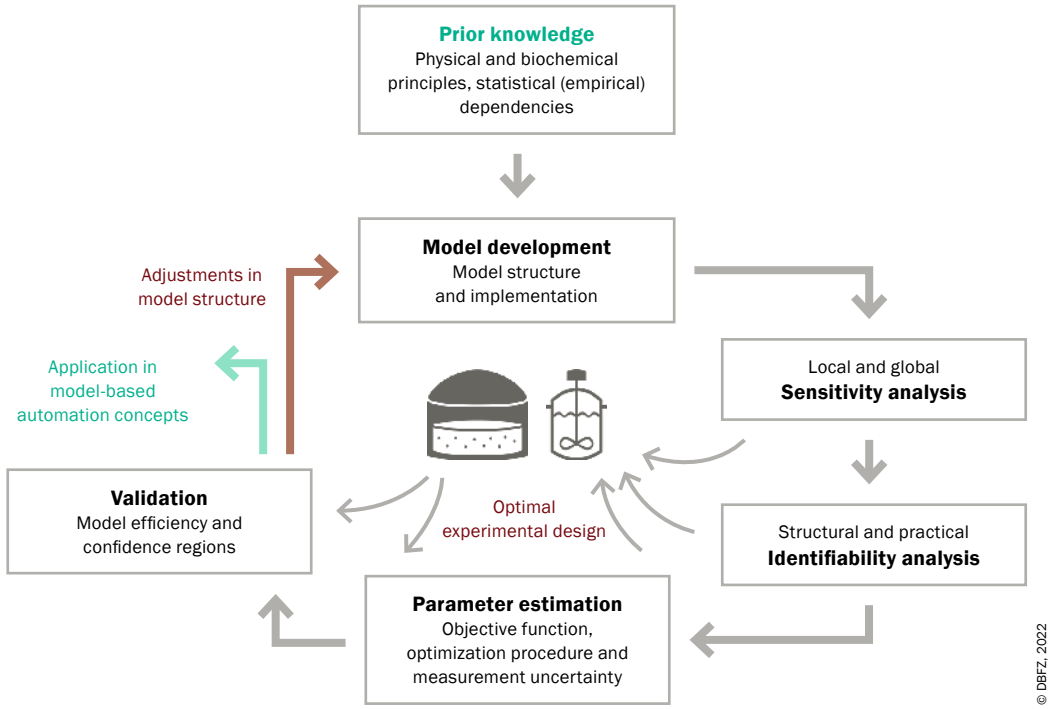

Fig. 14: General procedure for systematic model development and application

identification of unknown model parameters and process indicators (Figure 14).

For a robust assessment of the process and its efficiency, existing procedures based on fixed thresholds for individual stability indicators are revised with respect to an adaptive process analysis. In addition to available sensor data and analytical measurements, individual variables and parameters of applied simulation models are also available for automated process monitoring. Thus, implemented models can be used as a reliable basis for the development of robust control procedures for dynamic and demand-oriented process operation.

In addition to method validation based on laboratory experiments or typical data from industrial biogas plants, representative benchmark models of future-oriented plant concepts are to be developed. Taking into account the sensor technologies, laboratory analyses and effective measurement uncertainties at the plants, individual benchmark models will provide a standardized platform for the systematic evaluation, comparison and optimization of the various automation and operating concepts of agricultural biogas plants.

Milestones/Challenges

Simplified model structures of the established ADM1 were developed at the DBFZ in order to achieve a robust simulation of the processes in agricultural biogas plants [3]. The initial simulation results for process monitoring and control clearly prove that the different model variations are suitable for simulating the characteristic variables and process indicators of biogas technology (Figure 15). Whereas simplified model structures can be used to simulate (predict) dynamic biogas production, these models provide a reliable basis for model-based process control for demand-oriented substrate management and biogas production at existing biogas plants with low gas storage capacities [4]. Expanded model structures can be used to simulate relevant intermediate products and characteristic process indicators [5].

Current investigations are focusing on the detailed evaluation and advancement of existing reaction models and adaptive modelling procedures. In this respect, the specific objective of monitoring and process control has a considerable impact on which model structure is selected. Taking into consideration individual plant configurations (including individual substrate types) as well as available measurement and control technologies, suitable model structures are designed to meet the system requirements for robust process monitoring and control during regular operation. Based on existing datasets from laboratory and industrial processes, the initial results of using machine learning to simulate and predict established variables are currently being evaluated.

Representational laboratory experiments are planned for a detailed validation of model-

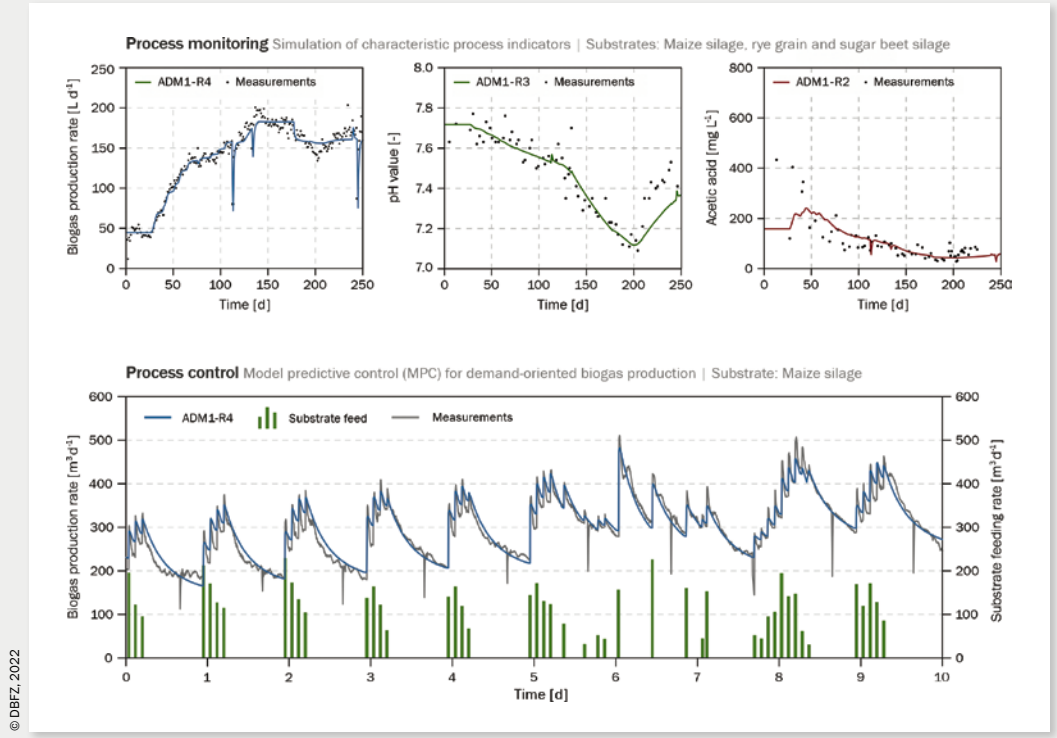

Fig. 15: Simulation results for model-based monitoring and demand-oriented process control [4,5]

based simulation and control concepts. Additional online sensors for the continuous measurement of characteristic process measurements (e. g., biogas composition) have been successfully installed. The first trials for the dynamic simulation of established variables and process indicators have started. With the implementation of an automated substrate feeding system, model-based control concepts will also be tested at laboratory scale using a variety of substrate mixtures in different operating modes (steady-state or dynamic operation), with different objectives (process flexibilization or base load) and process states (inhibition, nutrient limitation or malfunction).

Outlook

The interdisciplinary research project examines the systematic development of model-based monitoring and control procedures suitable for practical application. Thus, it forms an important link between scientific demonstration projects and the practical application of robust automation concepts during regular plant operation. Based on individual project results, suitable procedures for monitoring and process control can be implemented in control systems of full-scale anaerobic digestion plants. Using various plant and operating concepts (such as base load or demand-oriented operation), model-based automation procedures can evaluated and further developed to achieve reliable and efficient process operation. Building on project-based laboratory experiments, suitable methods for optimal experimental design for parameter identification are evaluated in industrial-scale anaerobic digestion plants.

Model-based automation processes also depend on reliable and precise sensor data. The results of the junior research group have found that this is essential to enable continuous (online) provision of influential process variables. This requires additional investigations into the development of innovative measurement and sensor technologies (including model-based soft sensors). Furthermore, a clear characterization of substrates and digestates is crucial if processes are to be simulated in a realistic and reliable way. Thus, project results can identify individual process variables, which promise to significantly improve model-based monitoring and control procedures.

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PROJECT PROFILE

Duration:
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Scientific contact:
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Project number:
2219NR333

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by decision of the German Bundestag

FNR
Fachagentur Nachwachsende Rohstoffe e.V.

The Research Focus Area “Anaerobic Processes”

Processes that use microorganisms to convert biomass under anaerobic conditions are the basis of a large number of biotechnological processes for producing energy carriers and materials. The research focus area “Anaerobic Processes” is developing efficient and flexible processes, primarily for biogas production, that can meet the requirements of the future energy system. Higher added value is achieved by coupling these with material utilisation processes. To this end, the research focus area is developing tools to monitor and control processes, concepts for flexible, low-emission plants and operating regimes, methods to evaluate and optimise efficiency, and processes to maximise material conversion, especially for difficult substrates.

Important reference projects and publications

Project: Bio2Geo – Development and demonstration of an innovative ecological hybrid power plant to couple bioenergy with geothermal energy to supply different consumer structures. Sub-project: Comprehensive system analysis with a focus on the economic aspects of plant operation. Federal Ministry for Economic Affairs and Energy, 1/10/2018–30/9/2021 (FKZ: 03ET1593B)

Project: BOGOTA-1 – Preliminary study for the development of a waste treatment concept for the city of Bogotá/Colombia, German Society for International Cooperation GmbH, 1/12/2020–31/1/2022 (FKZ: 81264100)

Project: IRMD – ENERGIEKONZEPT Innovationsregion Mitteldeutschland – Energy balance, potentials and measures for the innovation region of Central Germany (IRMD), Leipziger Institut für Energie GmbH, 1/7/2020–30/6/2021

Project: NovoHTK – Novel process for mono-fermentation of dry chicken manure, Federal Ministry for Economic Affairs and Energy, 1/9/2018–30/11/2021 (FKZ: 03KB137)

Project: Sensomix – Development and testing of sensor-based stirring systems in biogas plants to increase efficiency and process stability in flexible-load and demand-oriented biogas production, Federal Ministry of Food and Agriculture, 1/5/2020–30/4/2023 (FKZ: 2219NR387)

Publication: Dzofou Ngoumelah, D.; Harnisch, F.; Kretzschmar, J. (2021). “Benefits of Age-Improved Resistance of Mature Electroactive Biofilm Anodes in Anaerobic Digestion”. *Environmental Science & Technology* (ISSN: 1520-5851), Vol. 55, No. 12. pp. 8258–8266. DOI: 10.1021/acs.est.0c07320

Publication: Gökgöz, F.; Winkler, M.; Barchmann, T.; Weinrich, S.; Liebetrau, J.; Nelles, M. (2021). “Combining Electricity and Fuel Supply: Operational Strategies for Biogas Plants”. *Chemical Engineering & Technology* (ISSN: 0930-7516), Vol. 44, No. 1. pp. 183–193. DOI: 10.1002/ceat.202000268

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Publication: Weinrich, S.; Nelles, M. (2021). “Systematic simplification of the Anaerobic Digestion Model No. 1 (ADM1): model development and stoichiometric analysis”. *Bioresource Technology* (ISSN: 0960-8524), no. 333. DOI: 10.1016/j.biortech.2021.125124.

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5.3 Research Project “BIOFIT”

“Since 2019, a team from eight countries has been investigating various technical options and measures to increase the share of bioenergy in European industrial plants. The focus has been on five industrial sectors, which differed, for example, in plant size and previous use of bioenergy. There was great interest across all sectors, but also the need to optimise existing plants. The BIOFIT project was tasked with evaluating whether retrofitting and conversion measures to increase the integration of bioenergy are sustainable, time-saving and cost-saving approaches.”

Stephanie Hauschild
Project Leader

Bioenergy Retrofits for Europe’s Industry – BIOFIT

The coordination and support action BIOFIT “Bioenergy Retrofits for Europe’s Industry” is funded by the European Commission as part of the Horizon 2020 programme under grant agreement No 817999. The common goal of the 15 partners from eight different countries is to initiate and support retrofitting measures to increase the integration of bioenergy in five exemplary industry sectors:

_ Combined heat and power plants,
_ Fossil firing power plants,
_ First generation biofuel plants,
_ Fossil refineries, and
_ Pulp and paper production plants

KEYWORDS

Retrofitting measures
bioenergy
stocktaking
recommendations

Within the scope of the BIOFIT project, retrofitting describes the addition or replacement of plant features (e. g. plant components, feedstocks or auxiliaries) in order to substitute some of the fossil feedstocks and energy carriers with renewable alternatives. Retrofitting a plant can therefore result in both an increased use of biomass as a feedstock in the production of the primary product and energy, as well as the production of additional products from biomass.

The upcoming measures and reforms under "Fit for 55" alongside the greenhouse gas reduction targets of at least 55 % by 2030 (compared to the reference year 1990) [1] mean that special focus is being placed on increasing the sustainability of the processes under consideration. Biomass is and will remain an important component of renewable energy in the future. Increasingly integrating it into existing plant concepts can contribute significantly to reducing climate-damaging gases in the short to medium term.

The specific targets and measures may differ depending on the sector and as a result of additional policies. The partial or gradual substitution of fossil fuels with biomass in large-scale fossil-based combustion plants that provide energy and/or heat, can, for example, enable a regulated phase-out of coal [2]. In fossil-based refineries, the integration of biobased feedstocks into the existing process in the medium term as well as the addition (add-on) of a biobased pathway for using the existing infrastructure is also of interest in the short to medium term. For pulp and paper production plants, as well as in conventional biofuel production, there is a stronger focus on the use of by-products, the creation of a larger product portfolio, and the origin of the biobased feedstock. A higher flexibility of the plant and an increased efficiency are relevant aspects for sectors with bioenergy experience.

The project uses numerous methods and measures to determine the technical possibilities and illustrate their advantages. Drivers and barriers on the way to a successful retrofit are identified and discussed. The aim is to create a comprehensive knowledge base for the industrial sectors included in the study and to increase the willingness of companies to retrofit and convert their plants by showcasing projects that have already been implemented.

Methods/Activities

A mapping of the retrofitting measures in the five European industry sectors was carried out at the beginning of the project. The findings were processed and presented in a virtual map. Using plant profiles, selected showcase examples were examined in more detail and published on the project's website.

Building on these results, the DBFZ conducted an online survey as part of the "Industry Platform – Market Uptake" work package. This was primarily aimed at companies that had little or no experience of retrofitting. The aim was to find out what the companies regarded as being obstacles and which supporting framework conditions and drivers would have to be in place in order to pursue such a measure. The participants weighted various statements under four categories (technical, economic, ecological and policy) with regard to their specific sector. Increased plant flexibility, the fulfilment of climate goals, and increased plant efficiency were regarded as significant drivers across all sectors. Relevant barriers included an unstable policy framework, a lack of supranational coordination, and the availability of sufficient quantities of sustainable biomass. The survey responses revealed sector-specific differences when it came to the technical drivers. For the first generation biofuel sector, the diversification of the product portfolio and the increase in product quality were rated as major drivers in addition to the increased (feedstock) flexibility of the plant. Here, for example, the production of fuels for applications with few alternatives (e. g., shipping, aviation) or the processing of by-products (e. g., separation of CO_2 from ethanol or anaerobic fermentation) are possible options.

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Fig. 16: BIOFIT project meeting in Finland (visit to a wood-based biorefinery owned by the Metsä Group in Äänekoski)

In addition, public events were held in person and virtually as part of an Industry Fora led by the DBFZ. The meetings, organised for each industry by the project's sector experts, provided an opportunity to discuss the sector-specific challenges faced by the industries.

Milestones/Challenges

The BIOFIT project is funded as a Coordination and Support Action (CSA) under Horizon2020 and as such requires the interaction and participation of different stakeholders, representatives and actors. Accordingly, an Industrial Advisory Board was formed at the beginning of the project, which is involved in all project decisions. In addition, the implementation of events within the framework of the Industry Fora, study tours to best practice examples and international business missions to Brazil and Ukraine were planned. While the Industry Fora and study tours got off to a good start with a total of four physical meetings, the situation was challenging with the onset of the pandemic. Face-to-face events and business-to-business (B2B) meetings were cancelled and the study tours and business missions had to take place using a different format. The Industry Fora working group meetings were held virtually, which made them accessible to a wider circle, but also restricted networking opportunities.

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In terms of the promotion of retrofitting measures, the discussions and surveys revealed a number of substantive challenges that have already been briefly mentioned. Aspects that span the different sectors include long-term regulations that fluctuate or have yet to be clarified, complex regulatory structures and (for small operators) recordkeeping that is tied to copious paperwork, a discontinuation or lack of support mechanisms and the associated investment uncertainties. Competition over feedstock (for example with regard to the use of biobased oils and fats) is also regarded as a challenge for the future. The biofuel sector is also a comparatively young industry; most plants were not commissioned until 2005. Larger new investments are often not affordable at this stage. Moreover, biofuel plants have relatively small plant capacities compared to fossil fuel refineries. They have a "limited" customer base and are technologically very diverse and product-specific. A uniform, transferable technical solution is therefore not feasible.

The corresponding political and technical recommendations, which are intended to point out precisely these barriers and obstacles and provide specific approaches and options, have been formulated by the project and are available on the project's website. This is a major milestone of the BIOFIT project, which also benefited from the good networking opportunities and exchange of experience between the industries.

Outlook

The feasibility studies, the Industry Fora discussions and the best practise examples have shown that, especially in the sectors that exclusively have generated fossil-based products so far, retrofitting measures can make a short- to medium-term contribution to the decarbonisation and reduction of greenhouse gases for European industries. The co-firing of biomass in coal-fired plants or the co-processing of vegetable or pyrolysis oils in fluid catalytic cracking or in the hydrotreatment units of petroleum refineries are approaches that are currently under discussion. Industries that have already been using biobased feedstock for many years tend to concentrate on the utilisation of by-products, the creation of new sales markets, or the increase in efficiency of the processing line. The measures are specific to the location, process and feedstock. Here, the project can only provide impulses and indicate possibilities, while the solutions have to be found directly on site. However, the recommendations and developed networks will continue to have an impact and interested stakeholders can draw on the preliminary work of the BIOFIT project. Moreover, there are also concrete approaches in the Horizon Europe Framework Programme to promote the integration of cost-efficient technologies for the production of advanced biofuels at existing plants. Under this programme, the results of the BIOFIT project can be taken up and further pursued.

Sources

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→ **Further information:**
www.biofit-h2020.eu

PROJECT PROFILE

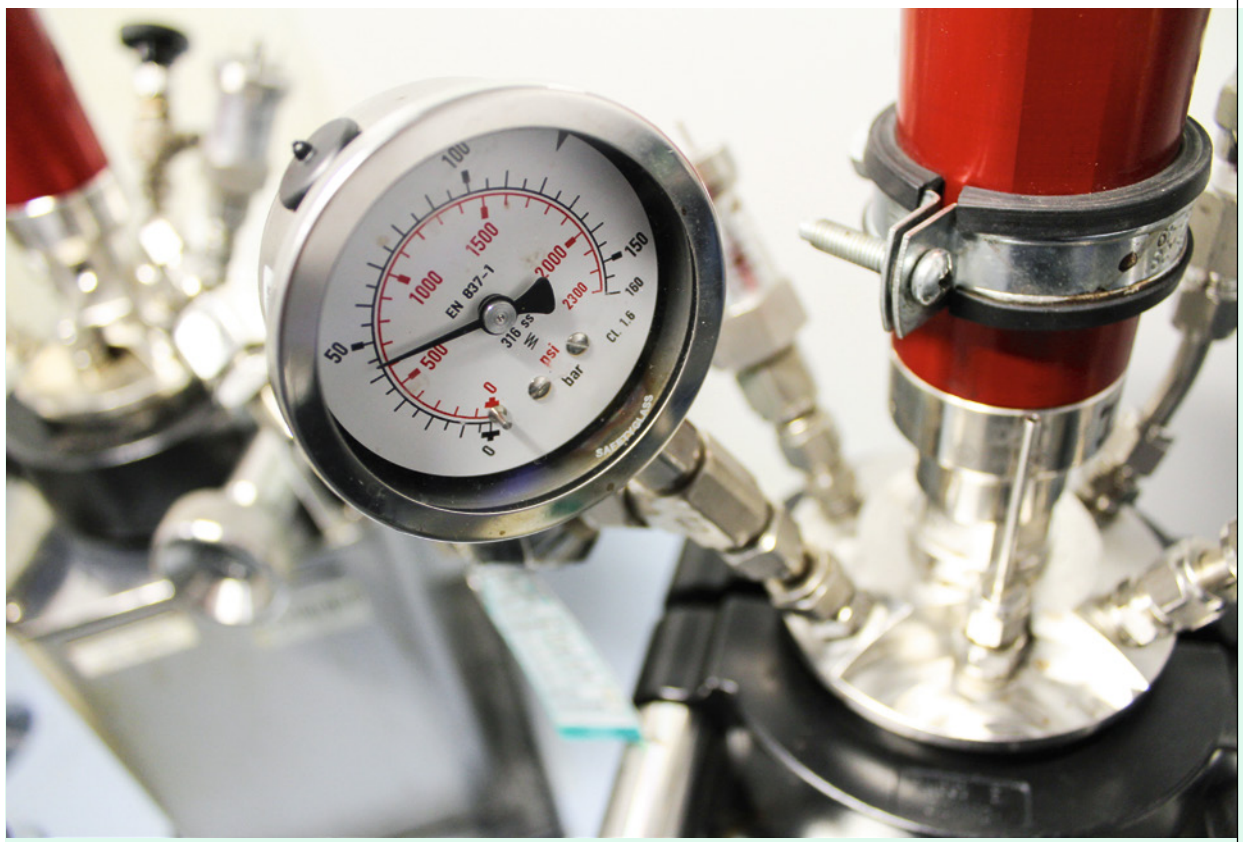
Duration:
1/10/2018–31/3/2022

Project partners:
B. T. G. Biomass Technology Group BV (coordination), Wirtschaft und Infrastruktur GmbH & Co Planungs KG (WIP), BEST – Bioenergy and Sustainable Technologies GmbH, DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Ethniko Kentro Erevnas Kai Technologikis Anaptyxis (CERTH), Teknologian tutkimuskeskus VTT Oy (VTT), Centro de investigaciones energeticas medioambientales y tecnologicas-CIEMAT, Energikontor Sydost AB (ESS), Javno Preduzece elektroprivreda Bosne I Hercegovine DD* (EPBiH), Technip Benelux BV, Stichting Wageningen Research, Swedish Biofuels AB, Ellinika Petrelaia AE (HELPE), Biocarburantes de Castilla y Leon SA

Scientific contacts:
Patrick Reumerman
(BTG, Coordinator),
Stephanie Hauschild
(DBFZ, Project leader)

Project number:
Grant agreement No. 817999

Funding body:
European Commission, H2020



The Research Focus Area “Biobased Products and Fuels”

The overarching research goal of the research focus area “Biobased Products and Fuels” is to contribute to biorefinery concepts as part of a sustainable bioeconomy through the use of innovative technological approaches. Here, the process engineering equipment of the biorefinery pilot plant is used and comprehensive methods for the multi-criteria technology assessment of individual processes and overall concepts for biorefineries are applied. A wide range of process engineering equipment and processes are used to map the complexity of the biorefineries. It is only through the meaningful combination of these process steps that biorefinery concepts emerge in which marketable products can be manufactured. For this reason, the technical equipment of the biorefinery pilot plant is designed to be inter-compatible so that a wide range of processing chains for biogenic raw materials can be investigated. In addition, the focus is increasingly on the automated acquisition of measurement data and automated plant operation. Work is naturally done in accordance with high scientific standards using statistical experimental design and evaluation methods as well as process simulation, databases and software tools to evaluate the technology.

Important reference projects and publications

Project: abonoCAR – WK abonoCARE – TP 2.V – Development of acid- and membrane-based phosphorus removal during HTC and energy-efficient drying of HTC coal on a laboratory scale, Federal Ministry of Education and Research, 1/4/2019–31/12/2022 (FKZ: 03WKDI2E)

Project: HTKkChem – Conversion of water- and carbohydrate-rich residues from biomass processing into chemicals and fuel components by hydrothermal processes, Federal Ministry of Education and Research, 1/11/2018–30/4/2022 (FKZ: 031B0674A).

Project: NormAKr – Standardisation of Alternative Fuels, Federal Ministry for Economic Affairs and Energy, 1/1/2020–31/12/2022 (FKZ: 03EIV241C)

Project: OpToKNuS – Development of a “toolbox” based on numerical models and practical measurements for the design and optimisation of thermochemical plants for the provision of energy from alternative fuels. Sub-project: Investigations on the DBFZ fixed-bed laboratory gasifier, Federal Ministry for Economic Affairs and Energy, 1/1/2020–31/12/2022 (FKZ: 03KB163B)

Project: PILOT-SBG – Research and Demonstration Project “Bioresources and Hydrogen to Methane as a Fuel – Conceptual Design and Implementation of a Pilot Scale Plant”, Federal Ministry of Transport and Digital Infrastructure (BMVI), 1/11/2018–31/12/2022

Publication: DBFZ (publ.) (2021). Naumann, K.; Müller-Langer, F.; Meisel, K.; Majer, S.; Schröder, J.; Schmieder, U. Background paper: Further Development of the German Greenhouse Gas Reduction Quota. Leipzig: DBFZ. 25 P

Publication: Knötig, P.; Etzold, H.; Wirth, B. (2021). “Model-Based Evaluation of Hydrothermal Treatment for the Energy Efficient Dewatering and Drying of Sewage Sludge”. *Processes* (ISSN: 2227-9717), Vol. 9, Nr. 8. DOI: 10.3390/pr9081346.

Publication: Körner, P. (2021). “Hydrothermal degradation of amino acids”. *ChemSusChem* (ISSN: 1864-564X), Vol. 14, Nr. 22. S. 4947–4957. DOI: 10.1002/cssc.202101487

Publication: Nitzsche, R.; Gröngröft, A.; Köchermann, J.; Meisel, K.; Etzold, H.; Verges, M.; Leschinsky, M.; Bachmann, J.; Saake, B.; Torkler, S.; Patzsch, K.; Rößiger, B.; Pufky-Heinrich, D.; Unkelbach, G. (2021). “Platform and fine chemicals from woody biomass: Demonstration and assessment of a novel biorefinery”. *Biomass Conversion and Biorefinery* (ISSN: 2190-6815), Vol. 11, Nr. 6. S. 2369–2385. DOI: 10.1007/s13399-020-00769-z.

Publication: Nitzsche, R.; Köchermann, J.; Gröngröft, A.; Kraume, M. (2021). “Nanofiltration of Organosolv Hemicellulose Hydrolyzate: Influence of Hydrothermal Pretreatment and Membrane Characteristics on Filtration Performance and Fouling”. *Industrial & Engineering Chemistry Research* (ISSN: 0888-5885), Vol. 60, Nr. 2. S. 916–930. DOI: 10.1021/acs.iecr.0c03256.

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5.4 Research Project “OptDienE”

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“The ‘OptDienE’ project investigated hybrid variants of the decentralised use of solid biomass in residential buildings with different heating requirements on the basis of various operating concepts. The results show that there are advantageous variants, so that solid biomass can be used where it can most efficiently serve the system.”

Kerstin Wurdinger
Project Leader

OptDienE – Options for the grid-serving operation of single-room stoves; Sub-project: system effects of single-room stoves

KEYWORDS

Single-room stove
solid biomass
demand side management
residential buildings
hybrid heating systems
security of supply

The transformation of the energy supply in the course of the energy transition is characterised by several megatrends: the decentralisation of energy provision, digitalisation of all areas of life, a dominant role of solar and wind energy in the electricity sector and, associated with this, a high volatility in electricity generation and an increasing intertwining of electricity, heat and mobility (sector coupling). The political and societal goal of reducing carbon dioxide emissions caused by the energy sector means that, in addition to the use of wind and solar energy as well as various types of storage, options will be sought in the near future that can ensure that energy demands can be met even when there is a high demand for electricity and heat and low renewable energy production. Solar energy has seasonal acyclic production peaks in relation to the heat demand peaks. The supply of wind energy is also not consistent in winter (for example during high-pressure weather conditions in January). Therefore, it is necessary to ensure that the simultaneously high demand for electricity and heat can be met during these periods.

There is much public debate about costly and investment-intensive storage methods that can bridge these volatility and supply vulnerabilities. Often the potential of biomass-based stoves, which are already established on the market, is overlooked. These can be used on demand and as a flexible, cross-sector option. From a technical point of view, these stoves could make a substantial contribution to covering peak loads. According to the latest data [1,2], it can be assumed that there are around 10 to 11 million single-room stoves (SRS) in Germany, i. e., on average there is an SRS in every second residential building and in about a quarter of all dwellings. With a conservatively estimated average heating capacity of 8 kW per SRS, the German residential building stock has a thermal capacity of 80 to 90 GW, which is already used on a regular basis for (auxiliary) heating or to provide extra comfort. This enables a load-shifting option [3] in which an electricity-based or fossil-based heater is replaced or supplemented by a biomass-based one.

The aim of the OptDienE project is to determine the current and future potential of biomass SRS for avoiding energy demand peaks caused by heaters in detached and semi-detached houses (DSDH) and to quantify this for Germany. For this purpose, SRS hybrid systems such as a) SRS+heat pump or b) SRS+solar heat+gas boiler were investigated based on different applications and conditions (e. g. building standards, operating behaviour of the SRS, size of the SRS). This was meant trigger discussions about the technical feasibility of instruments that would galvanise system operators and to provide political guidance. Depending on the progress made in climate protection, a considerable amount of the heat used in residential buildings will still be generated by fossil fuels during the transition phase up until 2050. This will either be through fossil-based heating systems (e. g. natural gas, oil) or through a share of fossil-based electricity in the electricity mix to run heat pumps. Therefore, climate-relevant criteria (greenhouse gases, particulate matter) are also taken into account in the assessment of the hybrid systems studied.

Methods/Measures

Using the TRNSYS simulation programme, the project partner, the Institute for Solar Energy Research Hameln (ISFH), modelled reference residential buildings with four different insulation standards and thus different heating requirements (see Table 2) as well as a number of combinable components in the heating system technology (heat pump, solar thermal system, buffer storage, gas boiler, biomass furnaces) and their hydraulic connections. The DBFZ contributed to the project by developing a log-burning stove model, parameterising the TRNSYS module for a pellet stove with a water bag, and programming the TRNSYS module to control the operation of an SRS. A variant matrix was developed for 480 simulations, each of which differed in their combination of building type, (hybrid) heating system and operating regime of the heating system; the variants were simulated by the ISFH.

Tab. 2: Building clusters considered in the "OptDienE" project

Building type modelled and simulated in "OptDienE"	Heating demand (HD) in kWh/(m²a)	Assignment to clusters based on "BioplanW"[4]
SFH20	25	DSDH, 30 (HD <30)
SFH45	58	DSDH, 45 (HD 30–60)
SFH100	107	DSDH, 90 (HD 60–120)
SFH200	287	DSDH, 180 (HD >180)

The results of the projects "BioPlanW" [4] and "Bio-Strom-Wärme"[5] [5], two projects conducted by the BMWK Bioenergy Research Network, were used to create the above-mentioned variant matrix and to forecast the quantification of the building clusters for the DSDH submarkets by 2050. In addition, data from [1,6,7] were used in the project to quantify potentials for the system-serving operation of pellet stoves, open fireplaces and wood-burning stoves in DSDH when these SRS types were part of a hybrid heating system.

Based on this data, the OptDienE project developed a methodology for transferring the simulation results of the project to Germany by combining relevant data (Figure 17). Simulation data [8,9] for DSDH from [4,5], clustered according to years and submarkets, were enriched with data on spatial location [6,7] for the year 2011 and assigned to a district based on the respective building structure of that district. Under the premise that an SRS can only be assigned to buildings that actually exist, the stock of SRS in Germany [1], modelled with linear regression and extrapolated to the federal states, was assigned to the respective stock of DSDH at the district level. It was assumed that a maximum of one SRS is allocated per building.

Milestones/Challenges

For the years 2030 and 2050, in both Climate Protection Scenario 80[6] (CS80) and Climate Protection Scenario 95 (CS95), the greatest potential for biomass combustion – in terms of the number of DSDH – was evident in cluster E90 (heating demand: 60–120 kWh/m²a) as a result of the building structure and SRS distribution. Quantitatively, the modelling of the allocation of 3.84 to 7.25 million SRS (pellet stoves, open fireplaces and wood-burning stoves) to DSDH in Germany results in a heating demand in the range of 41 to 78 GW for DSDH with an SRS for the year 2020 and under the CS80 scenario, which can theoretically be covered by electrical and/or thermal energy supply. This still leaves a heating power demand of between 25 and 48 GW in 2050 and under the CS95.

In order to compare the respective electricity demand for heat generation and the residual load, various evaluations were generated on the basis of the simulated variants (e.g., CO_2 reduction, reduction in electricity demand). Figure 18 shows the reduced electricity demand for heat supply in peak load times[7] and the residual load in 2020 (left, bottom) and 2030 (right, bottom) for four different variants based on building cluster, system concept and SRS operating regime. The upper part of the figure shows the annual electricity demand of each building from two different submarkets (i.e., building clusters) for the SRS operating regime "evening" as well as the SRS operating regime "morning and evening" in each middle section. In all four cases, 20 % of the SRS heat was provided to the room in which the stove was installed, the remaining 80 % was transferred to the heating system in which the SRS was integrated.

For the SRS operating regime "evening", the simulations showed a reduction in the annual electricity demand over the reference building without an SRS of about 16 % for both building clusters in the time slice between 6 am and 9 am and it was 45 % (DSDH, E45) and 73 % (DSDH, E90) lower between 6 pm and 9 pm. For the "morning and evening" operating regime, the reduction was similar for both time slices: for DSDH E45 it was around 58 % and for DSDH E90 around 77 %.

The interim project results were presented at several conferences and platforms (the 8th status conference "Biomass energy use"

[4] BioplanW – System solutions for bioenergy in the heating sector in the context of future developments."

[5] "Bio-Strom-Wärme – role of bioenergy on the electricity and heating market up to 2050 taking into account future housing stock"

[6] Climate protection scenarios with 80 and 95 per cent reduction in greenhouse gas emissions by 2050 over 1990 levels

[7] In the simulations, peak load times were set at 6 am–9 am and 6 pm–9 pm and SRS operations in these time slices were designated as the SRS operating regimes "morning", "evening" and "morning and evening".

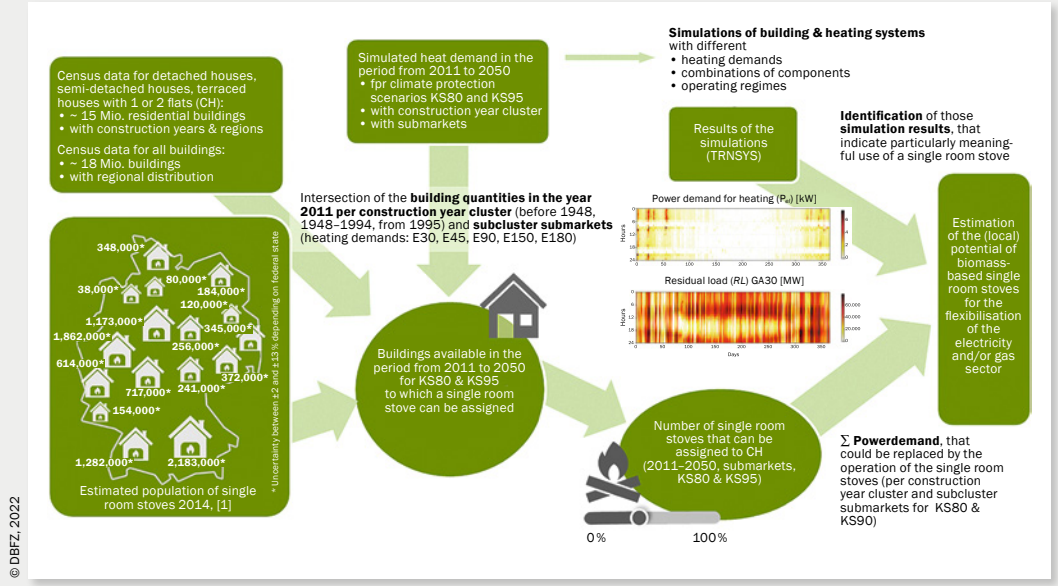

Fig. 17: Methodology for analysing potential

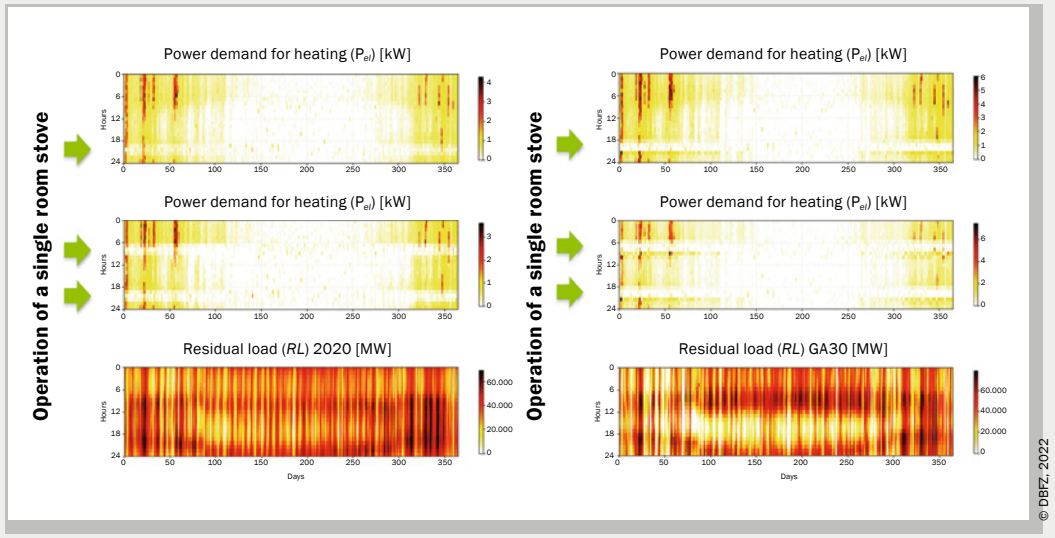

Fig. 18: Visualisation of the system contribution of the heating system without solar thermal energy. Left: DSDH, E45, heat pump with 4 kW pellet stove, right: DSDH, E90, heat pump with 8 kW log-fired SRS

2019, the specialist conference “Bioenergy & Energiewende Building” 2020, DBFZ’s annual conference in 2020, “BauSim” Graz 2020, FVEE’s annual conference in 2020, “Regenerative Energy Technology Conference RET. Con” Nordhausen 2020 and 2021, “Symposium Solarthermie und innovative Wärmesysteme” 2020, the 24th expert meeting “Arbeitskreis Holzfeuerung” at TFZ Straubing in 2021) as well as in an expert interview on the online platform pelletshome.com in 2020.

Outlook

The development and simulation of operating concepts for the cross-sectoral use of biomass in single-room stoves, as well as the results of these simulations support the research work of the DBFZ whose aim in the research focus area “SmartBiomassHeat” is to achieve the targeted system-serving control of the bioenergy systems under investigation and to develop system controls for integrating energy technologies and components. The project contributes to quantifying the potential for a more flexible contribution of solid biomass systems (wood pellets, logs) to the coupled energy system electricity/heat through load shifting potentials in Germany’s residential sector. The simulations resulted in reductions in electricity demand through SRS of between 7 % and 88 % based on the respective ratio of specific heating energy demand to SRS output. A system contribution of the investigated hybrid systems therefore appears economical for some variants of hybrid heating systems. At the same time, the exploitation of the existing potentials requires market products that monetarily recognise the offer of a load shifting option on the consumer side. In terms of sector-coupled energy provision, the regionally heterogeneous building structures in combination with the regional potentials for the use of biomass SRS can be taken into consideration if the required electricity cannot be completely covered by renewable sources.

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→ **Further information:**
www.energetische-biomassenutzung.de/en/projects-partners/details/project/show/Project/OptDienE-589

PROJECT PROFILE

Duration:
1/8/2018–30/11/2021

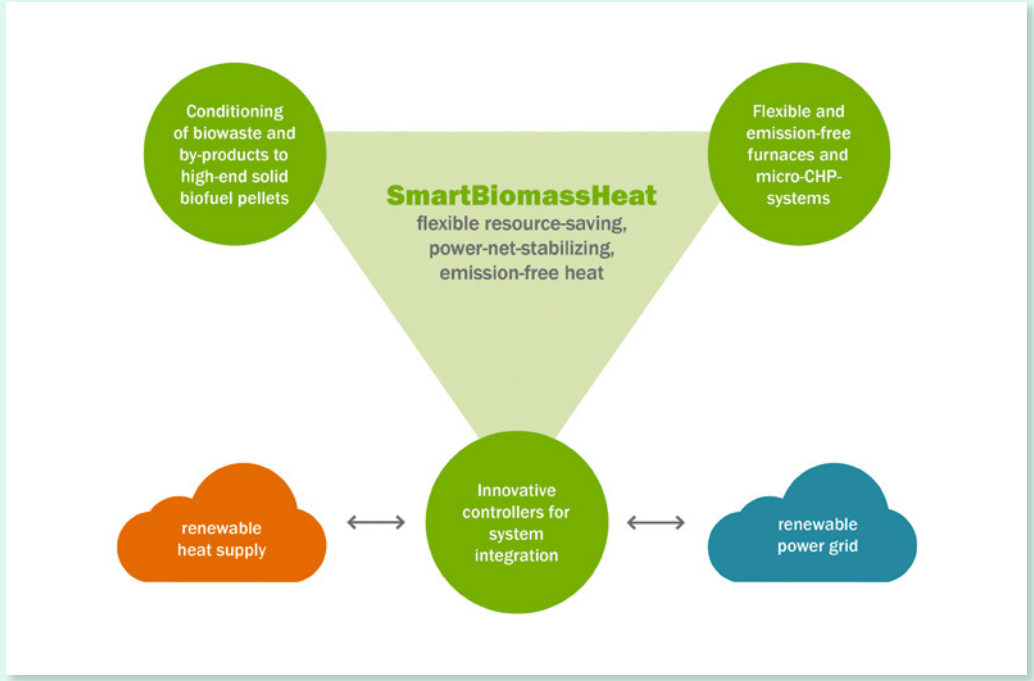
Project partner:
ISFH – Institut für Solarenergieforschung GmbH

Scientific contact:
Kerstin Wurdinger

Project number:
03KB138

Funding bodies:
Federal Ministry for Economic Affairs and Energy/
Project Management Jülich

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag
Projektträger Jülich Forschungszentrum Jülich



The Research Focus Area "SmartBiomassHeat"

The research focus area concentrates on the small-scale, renewable supply of heat to buildings and building complexes on up to villages and neighbourhoods using alternative renewable energy sources and smart heating technology networks that are based on biomass, primarily from residues, by-products and waste. The overarching goal is to make the best technological and economic use of all renewable heat sources through the flexible demand-oriented use of biomass-based heating technologies. The entire chain must be mapped, investigated (both on an individual basis and as a whole), simulated and optimised – from the refinement of biomass fuels via new conversion plants, to the integration of biomass heating systems in the heating and power grid. These biomass heating systems are also designed as future heat-power-cooling systems. By developing the necessary technical components and combining these with the development of control systems, these systems can be optimised for flexible operation (including for micro and small CHPs) as well as for efficient (smart) operation that is environmentally friendly, economic, safe, demand-oriented, flexible and sustainable.

→ **Further information:**
www.smartbiomassheat.com

Important reference projects and publications

Project: BioBeton – Biomass-based and sustainable production of concrete products, German Society for International Cooperation GmbH, 1/1/2021–30/6/2023 (FKZ: KK5045102KI0)

Project: ETH-Soil – Soil improvement in Ethiopia through use of agricultural residues for energy and as a material with a special focus on education and training, Federal Ministry for Economic Cooperation and Development, 1/7/2021–31/12/2026

Project: HTPyr1 – Preliminary study on the development of a high-temperature pyrolysis plant for power generation and the utilisation of residues, Federal Ministry of Education and Research, 1/7/2021–30/06/2022 (FKZ: 03EI5433)

Project: IRASIL – Investigation of ash behaviour during the thermo-chemical conversion of pre-treated, silicon-rich biomass for power and heat generation and utilisation of the resulting ash for the extraction of inorganic framework compounds with a wide range of possible applications, Federal Ministry of Food and Agriculture, 1/1/2018–30/6/2021 (FKZ: 2816DOKI03)

Project: ZirkulierBar – Intercommunal acceptance for sustainable valorisation of sanitary by-product streams. Nutrient recovery – from linear sanitary flushing to circular nutrient recycling, Federal Ministry of Education and Research, 1/7/2021–30/6/2024 (FKZ: 033L242H)

Publication: Krüger, D.; Mutlu, Ö. Ç. (2021). "Demonstration of a Top-Lit Updraft Based Pyrolytic Burner with Low Emission Operation and Automatic Process Control". *Energies* (ISSN: 1996-1073), Vol. 14, Nr. 13. DOI: 10.3390/en14133913.

Publication: Li, H.; Mou, H.; Zhao, N.; Yu, Y.; Hong, Q.; Philbert, M.; Zhou, Y.; Beidaghy, H. D.; Dong, R. (2021). "Nitrogen Migration during Pyrolysis of Raw and Acid Leached Maize Straw". *Sustainability* (ISSN: 2071-1050), Vol. 13, Nr. 7. DOI: 10.3390/su13073786.

Publication: Mutlu, Ö. Ç.; Büchner, D.; Theurich, S.; Zeng, T. (2021). "Combined Use of Solar and Biomass Energy for Sustainable and Cost-Effective Low-Temperature Drying of Food Processing Residues on an Industrial Scale". *Energies* (ISSN: 1996-1073), Vol. 14, Nr. 3. DOI: 10.3390/en14030561.

Publication: Zeng, T.; Mlonka-Mędrala, A.; Lenz, V.; Nelles, M. (2021). "Evaluation of bottom ash slagging risk during combustion of herbaceous and woody biomass fuels in a small-scale boiler by principal component analysis". *Biomass Conversion and Biorefinery*, Vol. 11, Nr. 4. S. 1211–1229. DOI: 10.1007/s13399-019-00494-2.

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Fig. 19: Pilot plant for the production of biogenic silica from oat and spelt husks, model: Oekotherm 49 kW

5.5 Research Project “PaCoSil”

“The ‘PaCoSil’ project is looking into how regenerative heat can be generated with biogenic residues that are rich in silicon and regionally available in Germany. The heat-controlled production is coupled with the material use of the biogenic silicon dioxide produced as a by-product from silicon-rich biogenic residues. The project’s economic viability is evidenced by the fact that heat-controlled production can be combined with the material use of the ash fractions.”

Prof. Dr. Ingo Hartmann
Project Leader

PaCoSil – Combustion of regionally available residues for the energetic use of biomass and for the coupled production of biogenic silica for particulate matter precipitation processes

In the PaCoSil project, silicon-rich biogenic residues that are regionally available in Germany and used to generate regenerative heat, are also being investigated in combination with silica-enriched porous X-ray amorphous solids so that they can be put to material use in environmental technology processes for particulate matter precipitation. Silicon-rich biogenic residues are produced as a by-product during the material

KEYWORDS

Biosilica
particle filtration
particulate matter
emission reduction
residue combustion

utilisation coupled to the heat-controlled production. The project's economic viability is evidenced by the fact that heat-controlled production can be combined with the material utilisation of the ash fractions. The focus of the project is therefore on the use of the material as energy and requires technical developments to implement the process steps. Oat and spelt husks are used as silicon-rich and regionally available biogenic residues. A manufacturing process to produce porous silicon dioxide (SiO_2) from silicon-rich biogenic residues was developed as part of previous investigations. The focus was on the use of rice husks. Silicon dioxide is extracted from the biomass through a thermal process and an upstream chemical-physical process. This SiO_2 is used as a filter material for particulate matter precipitation (www.ete-ing.de/en/fine-dust-filter/) in specially developed baghouse filter systems. This will be examined by the project in two applications:

1. Flue gas cleaning of biomass furnaces for residual and waste materials
2. Ambient air purification of factory and process air in production processes.

The previous findings [1–3] will be taken up and expanded on and focus will be placed on residues that are available locally or regionally in Germany. The project partners will carry out basic laboratory investigations up to practical demonstration tests in order to develop the overall process and the technical applications and thus prove the feasibility. The aim is to investigate how well the SiO_2-enriched powdery material from the combustion process – biogenic silica from different raw material sources – can be used as a particulate matter filtration material. The necessary process engineering components are to be developed and optimised on a pilot plant scale and evaluated in during the operation of two field plants (combustion exhaust gas and ambient air).

Methods/Measures

This project involves research into the environmentally friendly combustion-based production of biogenic silica from regionally available oat and spelt husks. Since the heat generated in the process can be utilised efficiently, the aim is to enable the coupled material-energetic use of silicon-rich biogenic residues within the bioeconomy on the basis of regionally available biomass.

As the project coordinator, the DBFZ is responsible for coordinating the individual research tasks, the scientific development of synergies, component integration, the development of optimisation approaches and the organisation, implementation, scientific monitoring and evaluation of the test bench and field measurements. The DBFZ will also drive forward the design and testing of the baghouse filter system for exhaust gas cleaning. In addition, a concept for recycling the filtration powder with attached particulate matter is being developed, with experimental investigations into further applications of the biogenic silica.

The project partner A.P. Bioenergietechnik GmbH will first investigate and compile the boundary conditions for the entire recycling path. The focus is on the properties of the oat and spelt husks as fuels and their effects on fuel handling, the combustion process and ash handling in an Ökotherm boiler (see Figure 20).

The aim is to achieve a stable, automated operating process that complies with the emission values that apply during combustion and which produces a high-quality silicon-rich ash that can be used as a precoat material in filter processes. Combustion tests on a test bench are used to identify the combustion properties under practical conditions. Based on this, the heating system is redesigned for husk fuels by installing and modifying the fuel supply system, the combustion air supply system, the ash removal system and the combustion chamber. The heating system's control unit is adapted to thermally utilise husk fuels and to generate silicon-rich ash, which can be used as a filter material in gas purification (see Figure 21).

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Fig. 20: Front view of the internal combustion chamber (top) of an Ökotherm boiler and flame image (below) of woodchip combustion in the Ökotherm unit

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Fig. 21: Fabric filter for particulate matter precipitation

The adaptations are verified by long-term testing of an operational unit over two heating periods. The ash is to be used as a filter material in the unit's fabric filter system. Further optimisation steps will be carried out between the heating periods so that by the end of the project, a heating system will have been created that can permanently run on regional husk fuels and produce high-quality ash for material use.

Milestones/Challenges

Up to now, there have been no practical studies in Germany on the combustion of locally

available biogenic residues with a high Si content, as these biogenic residues cannot yet be used by farms for energy and material purposes as part of a coupled process. The results aimed for in the project are very promising if the project goals are achieved. The project should demonstrate that biogenic silica from biogenic residue combustion has very interesting properties with regard to material use and applicability, whereby only biogenic residues from Germany are to be used for which there is no competition over use. The PaCoSil project is specifically focused on regional use because the industrial potential for the use of valuable Si biogenic resources has not yet been exhausted and has been expanded accordingly. However, neither are combustion units offered on the market in Germany for the combined thermal and material use of biogenic residues with a high Si content, nor is silica being extracted from biogenic residues on a commercial basis. Thus, no fully-developed units and processes can be used at present, which leads the project to use pilot plants and processes.

The project will determine the quantities of biogenic residues available in Germany per season and their current utilisation pathways. Competing use with higher-value pathways such as animal feed is to be avoided as much as possible. The project partners are developing a practice-oriented research plant that can be used to combust silicon-rich biogenic residues from Germany in order to generate coupled energy and biogenic silica. Particular attention is being paid to the combustion process in order to obtain a mesoporous SiO_2-rich powder from the regional biogenic residues, which can be used as a particulate matter filtration medium. A very important requirement for the practice-oriented demonstration unit is that the most efficient form of energy extraction as possible be used. The overall aim is to develop a marketable process for biomass furnaces ranging from 0.1 to 5 MWth, with efficient energy utilisation coupled with the generation of a sufficiently high ash quality. In addition, the potential for producing silica from local biogenic sources is to be further investigated and, at best, utilised.

Three scenarios are considered when identifying the most environmentally friendly use of the biogenic residues: (i) supplying an industrial building with thermal energy at the installation site, (ii) supplying a local heating network in a bioenergy village and (iii) co-generating heat and electricity.

Outlook

A defined production process for silica from biogenic sources that is close to the market would lower costs considerably, making it attractive to operate a plant using biogenic residues from local resources. This would contribute to the reduction of CO_2 emissions while preserving regional jobs. In addition, locally grown Si-rich biogenic material, such as oat and spelt husk ash, would aid in the effective and sustainable cleaning of exhaust gas, exhaust air and ambient air through the precoating of fabric filters.

In the future, non-woody biogenic residues and waste materials will increasingly be used in energy generation, whereby the use of alternative biogenic solid fuels will mainly occur in ranges over 100 kW. In this heat capacity range, the emission requirements of the 44th BImSchV and TA Luft apply, which can only be met through the use of secondary emission control measures. With the development of particulate matter filter powder that is based on biogenic SiO_2, health problems can be reduced that would result from toxic particles in the ambient air if no effective dust precipitation takes place.

Sources

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→ **Further information:**
www.energetische-biomassenutzung.de/en/projects-partners/details/project/show/Project/PaCoSil-700

PROJECT PROFILE

Duration:
1/7/2021–30/6/2024

Project partner:
A. P. Bioenergietechnik GmbH,
Träglhof 6,
92242 Hirschau,
Deutschland
(www.oeko-therm.net)

Scientific contact:
Dr. Steffi Formann

Project number:
03EI5436

Funding bodies:
Federal Ministry for
Economic Affairs and Energy/
Project Management Jülich

Supported by:
Federal Ministry for Economic Affairs and Energy
on the basis of a decision by the German Bundestag

Projektträger Jülich
Forschungszentrum Jülich

The Research Focus Area “Catalytic Emission Control”

The vision of a climate-neutral and sustainable bioeconomy – and the premises associated with this – place very high demands on the research focus area “Catalytic Emission Control” when it comes to pollutant-free bioenergy use. In particular, increased use in the future of biogenic residual and waste materials in increasingly varying qualities represents a challenge for emission-free use. The focus here is on controlling the emissions of the combustion processes of bioenergy carriers through the use of and in combination with solid-state catalysts. There must be an extensive reduction in the greenhouse gas methane (CH_4), toxic volatile organic compounds (VOC), semi-volatile and low-volatile hydrocarbons, such as polycyclic aromatic hydrocarbons (PAH) and polychlorinated dioxins and furans (PCDD/PCDF), soot particles (carbon black), and nitrogen oxides (NO_X). The objective of the research focus area is to investigate recyclable and cost-effective catalysts that are stable over the long-term and at high temperatures and which contain no, or a significantly lower amount of precious metals. In particular, combining catalysts with additional emission abatement processes needs to be investigated in detail.

Important reference projects and publications

Project: A+BiOx – Thermo-chemical conversion of silicon rich biomass residues for the production of heat and power, and the combined generation of mesoporous biogenic silica for material application; Federal Ministry of Food and Agriculture/Federal Agency for Agriculture and Food, 1/1/2020–31/12/2022 (FKZ: 2819D0KA05)

Project: BioFeuSe – New sensor technology for process optimisation of SCR processes and particle separation at biomass combustion plants, Federal Ministry for Economic Affairs and Energy/Project Management Jülich, 1/7/2021–30/6/2024 (FKZ: 03EI54346A)

Project: GASASH – Thermo-chemical conversion of residues in a gasifier CHP with coupled ash recovery; sub-project: Investigations on product gas quality, CHP emissions, emission reduction measures and ash utilisation, Federal Ministry for Economic Affairs and Energy/Project Management Jülich, 1/9/2018–30/6/2021 (FKZ:03KB139A)

Project: KaRo – Catalytic shell-and-tube reactor for the total oxidation of fuel gases from the thermal conversion of solid biofuels for low-emission regenerative heat generation, Sächsische Aufbaubank, 1/10/2019–30/6/2022 (FKZ: 100332481)

Project: UVV – Joint project: Emission reduction strategies for environmentally compatible combustion (UVV) on the basis of current research results; sub-project 1: Theoretical and experimental investigations, coordination; Federal Ministry of Food and Agriculture/Agency for Renewable Resources e.V., 1/4/2019–31/3/2022 (FKZ: 22038418)

Publication: Prempeh, C. O.; Formann, S.; Schliermann, T.; Beidaghy, H. D.; Nelles, M. (2021). “Extraction and Characterization of Biogenic Silica Obtained from Selected Agro-Waste in Africa”. Applied Sciences, Vol. 11, Nr. 21. S. 10363. DOI: 10.3390/app112110363.

Publication: Formann, S.; Schliermann, T. (2021). Feasibility study of in-situ production of biogenous silica from rice husks of region Mekong Delta, Vietnam. Lecture held: GIZ-DBFZ expert discussion, [online], 18/11/2021

Publication: König, M.; Hartmann, I.; Varas-Concha, F.; Torres-Fuchslocher, C.; Hoferecht, F. (2021). “Effects of single and combined retrofit devices on the performance of wood stoves”. *Renewable Energy* (ISSN: 0960-1481), Nr. 171. S. 75–84. DOI: 10.1016/j.renene.2021.02.050.

Publication: König, M.; Müller, M.; Hartmann, I. (2021). “Emission reduction process for the energetic use of biogenic residues”. IOP Conference Series: Earth and Environmental Science (ISSN: 1755-1307), Nr. 642. DOI: 10.1088/1755-1315/642/1/012006.

Publication: Hartmann, I.; Thiel, C.; Wiest, J.; Kossack, W.; Lehmenkühler, L.; Ho, J.; Krämer, G.; Hess, D. (2021). “Development of a low-emission single-room combustion system fed with precision wood chips”. Joint project: Development of a low-emission single-room firing system for quality assured woodchips produced according to demand; funding code: 22016817. Lecture held: 15th Rostock Bioenergy Forum, [online], 16–17/6/2021.

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6 Promoting Young Talent

One of the DBFZ's key objectives is to promote young scientists in the field of bioenergy and the bioeconomy. To fulfil its scientific mission, the DBFZ continuously develops its staff and expands its interdisciplinary expertise and extensive research infrastructure. Young scientists are fostered primarily through the supervision of bachelor's, master's and doctoral dissertations (see p. 130). Employees also benefit from a broad range of continuing education courses and the DBFZ's doctoral programme.

Doctoral Programme

The DBFZ's doctoral programme has been in place since 2013 and offers doctoral researchers a variety of opportunities to delve deeper into an aspect related to bioenergy and the bioeconomy and to utilise their acquired knowledge and findings through applied research. PhD students have access to state-of-the-art technology in the DBFZ's laboratories, pilot plants and offices to investigate and work on their research topics and receive expert supervision by one or two experienced DBFZ scientists. This provides an additional guarantee of high-quality research. They receive academic supervision by renowned universities in Germany with which the DBFZ maintains a large number of research collaborations. PhD students are involved in research life at the DBFZ from the very beginning and participate in ongoing projects. Regular participation in high-level scientific events (e.g., the Doctoral Colloquium BIOENERGY and DBFZ Annual Conference) introduces them to the scientific community early on. They are also given the opportunity to consolidate their experience within the framework of committee work.

Tab. 3: Doctoral programme figures at a glance (as of 1 February 2022)

Total number of doctoral projects in 2021	**67**
Projects supervised at the DBFZ	44
Projects supervised at the Universities of Leipzig and Rostock and the UFZ	23
Number of completed projects	8
Cooperation with national and international universities and universities of applied sciences	11

Fig. 22: Participants at the 4th Doctoral Colloquium BIOENERGY

Doctoral Colloquium BIOENERGY

The Doctoral Colloquium BIOENERGY took place for the fourth time on 13/14 September 2021 – this time at the premises of the cooperation partner KIT in Karlsruhe. A total of seventy participants from 14 countries (including Brazil, Canada, China, Ghana, Greece, Iran, Germany and Austria) took advantage of the opportunity to exchange views – once again in person – on a wide range of topics in the field of bioenergy/bioeconomics. In addition to an extensive poster session, the young scientists covered a wide range of topics in a total of twenty presentations, from "Potentials of agricultural residues and current problems of the biogas industry in China" to "Bioenergy villages in Germany – funding programmes and obstacles" and "Catalytic hydrothermal gasification of glycerine". Various other input made for an extremely exciting and thematically multi-layered event. The two-day conference was rounded off with a plant tour, live discussions and extensive networking activities. The conference reader can be downloaded for free as a PDF from the website. The next event will take place on 13/14 September 2022 at the DBFZ in Leipzig and will be jointly organised with EERA Bioenergy.

→ **Further information:**
www.doc-bioenergy.de

BIOENERGY
DOC2022
5TH DOCTORAL
COLLOQUIUM BIOENERGY

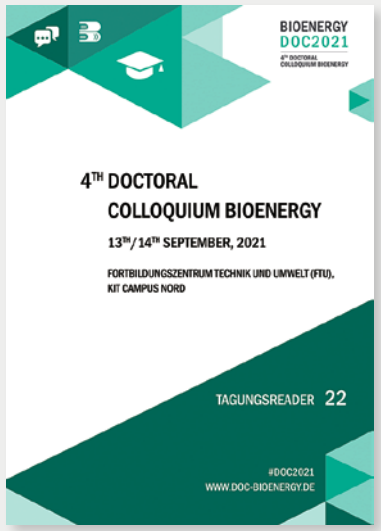

Fig. 23: Conference reader of the 4th Doctoral Colloquium BIOENERGY

Example of a dissertation by Hossein Beidaghy Dizaji

Fig. 24: PhD student Hossein Beidaghy Dizaji

Ash-related aspects during the thermo-chemical conversion of leached, silicon-rich biomass assortments

Around 800 million tonnes of paddy rice is produced annually around the world [1]. Approximately 20–25 wt.% db of paddy rice is rice husk (RH) and 40–60 wt.% is rice straw (RS) [2,3]. Every year, open burning of these agricultural residues causes environmental and health problems, especially in developing countries. The fuel ash of these materials contains a high amount of silica (>70 wt.% db), which makes it a potential source for biogenic silica production. High-quality silica has various advanced applications such as catalysis, drug delivery and energy storage if the ash that is produced fulfils several criteria which are listed in Figure 25.

Scientific research on the impact of fuel pre-treatment and conversion parameters is still needed to ensure that the silica-rich bottom ash has the desired quality for use as a material. The following objectives were addressed in Hossein Beidaghy Dizaji's PhD thesis "Ash-related aspects during the thermo-chemical conversion of leached, silicon-rich biomass assortments":

- A comprehensive literature review and a systematic experimental investigation to clarify the effect of fuel pre-treatment and combustion parameters on the quality of biogenic silica and bottom ash slag formation.
- Clarification of macroscopic and microscopic aspects of the bottom ash transformation mechanism and the role of different ash-forming elements on the ash transformation reactions.
- Prediction of slag formation and the quality of the biogenic silica using thermo-dynamic equilibrium calculations, relevant fuel indexes defined by the chemical composition of the fuel ash, and ash viscosity calculations.

The results of the project have been published in several peer-reviewed papers [4–7] and can be summarized as follows:

- Unlike chemical fuel pre-treatment, the application of fuel blends is limited to the mitigation of slag formation in the ash and the production of high-quality biogenic silica. For rice straw, leaching with citric acid is more effective, while for rice husks, pretreatment with water is sufficient to improve silica quality and avoid ash slagging.
- The purity and specific surface area of the biogenic silica from the combustion of the leached rice husks enables it to be used in medical applications, such as drug delivery.
- Below a crystalline content in the ash of about 10 wt.%, the conversion temperature

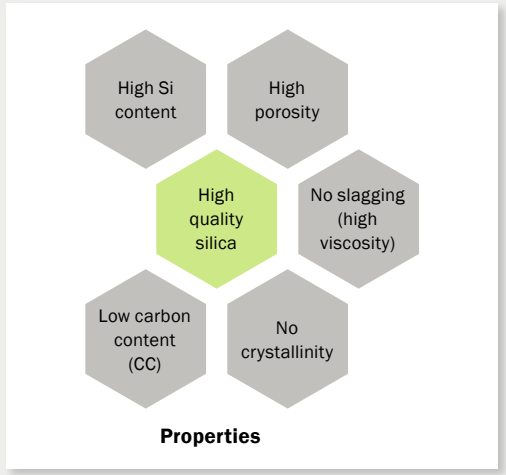

Fig. 25: Parameters that determine high-quality biogenic silica

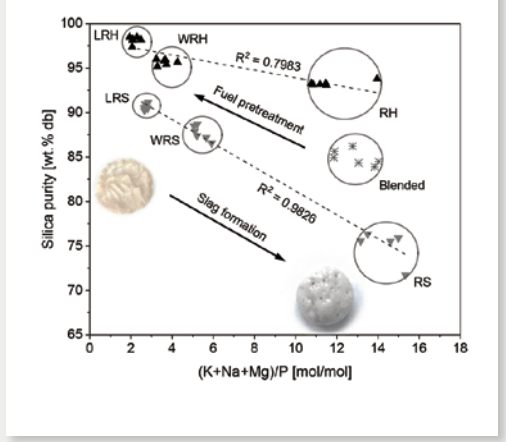

Fig. 26: Silica purity as a function of the new fuel index. Abbreviations: acid-leached rice husk (LRH), acid-leached rice straw (LRS), rice husk (RH), rice straw (RS), blended 50 wt.% db rice straw with 50 wt.% db rice husk (50RS-50RH), water-washed rice husk (WRH), water-washed rice straw (WRS)

as well as the type of fuel pre-treatment affect the quality of the biogenic silica. Therefore, to produce high quality biogenic silica, the crystalline fraction of the ash should be kept below this threshold.

_ A newly defined fuel index (K+Na+Mg)/P [mol/mol] offers a high potential for classifying the slagging behavior of the ash and the purity of the biogenic silica (Figure 25).

Future investigations should consider the following aspects:

_ The temperature, time and acid concentration of the chemical fuel pre-treatment needs to be optimised since this has a considerable influence on the slag formation in the ash and the quality of the biogenic silica.

_ Technical upscaling of the chemical fuel pre-treatment and densification of the fuel should be considered so that it can be used in small- and medium-sized combustion plants.

_ The entire supply chain should be analysed using a life cycle analysis (LCA) to evaluate sustainability aspects.

_ The use of Si-rich biomass in combustion plants should be investigated using CFD simulations to avoid combustion temperatures above 900 °C, which may lead to crystallization in the ash.

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DBFZ

List of current dissertations at the DBFZ

(As of 1 February 2022)
* Successful completion in 2021/2022

Ackermann, Konstantin
Operational optimisation using digital twins
Pending approval

Adam, Roman
Further development of the biomass compaction process using DEM simulations
Technical University Berlin

Beidaghy Dizaji*, Hossein
Ash-related aspects during the thermo-chemical conversion of leached silicon-rich biomass assortments
University of Leipzig/
Iran University of Science and Technology (IUST)

Bindig, René
Procedure for developing catalysts for emission reduction at incineration plants
Martin Luther University
Halle-Wittenberg

Brosowski*, André
National resource monitoring for biogenic residues, wastes and by-products – Development of a systematic data collection, management and assessment for Germany
University of Leipzig

Büchner*, Daniel
Optimised control strategies for pellet-solar combisystems to increase system efficiency while minimising energy costs
Technical University Dresden

Chang, Yingmu
Improvement of biogas use of agricultural residues in China combined with Germany's experience
University of Leipzig

Delory, Felix
Model-based monitoring of anaerobic digestion plants
Pending approval

Dernbecher, Andrea
Numerical study of emissions from small-scale biomass combustion plants
Technical University Berlin

Dietrich, Sebastian
Biogas upgrading to H-gas by direct synthesis of short-chain hydrocarbons
Technical University Berlin

Dietrich, Steffi
Evaluation of policy instruments to promote bioeconomic solutions for agricultural residue utilisation
Martin Luther University Halle-Wittenberg

Dotzauer, Martin
Economic evaluation of policy instruments to achieve the expansion targets of bioenergy plants in the electricity sector using object-oriented programming
University of Leipzig

Gallegos, Daniela
Optimisation of ensiling fermentation of elodea genus for biogas production
University of Rostock

Gebhardt, Heike
Heating network 4.0 – options for using solid biomass in decarbonised heating networks
Technical University Dresden

Hahn, Alena
The role of smart bioenergy in combination with CO_2 removal in decarbonisation scenarios
University of Leipzig

Hellmann, Simon
Robust and adaptive control of anaerobic digestion plants
Technical University Chemnitz

Hirschler, Olivier
Potential of renewable raw materials to replace peat as a substrate feedstock in German horticulture
University of Leipzig

Karras, Tom
Biomass supply costs for biogenic residues
University of Leipzig

Kirsten*, Claudia
Contribution to optimising the pelleting behaviour of fermentation residues and landscape hay and their blends
Technical University Berlin

Kirstein, Niels
Future use of biogenic solid fuels against the background of the two-degree target
University of Leipzig

Klüpfel, Christan Paul
Hydrothermal liquefaction of residual biomass
Technical University Berlin/
Aarhus University, Denmark

Köchermann, Jakob
Hydrothermal treatment of wood hydrolysates for the production of furan derivatives
Technical University Berlin

König, Mario
Investigation of the development and utilisation of Novel SCR-catalysts to reduce nitrogen oxides from the waste gas of the thermochemical conversion of biogenic solid fuels
Martin Luther University Halle-Wittenberg

Kurth, Matthis
Development, characterisation and modelling of a water separating membrane to increase the turnover of the methanation process
Technical University Berlin

Meola, Alberto
Artificial intelligence for process simulation of anaerobic digestion plants
University of Leipzig

Ngoumelah, Daniel Dzofou
Development of microbial electrochemical technologies for material and energetic use of the raw liquid manure of humans and animals
University of Leipzig

Nieß, Selina
Investigation of methanation catalysts for the upgrading of purified biogas in continuous operation
Technical University Berlin

Nitzsche, Roy
Adsorption and membrane filtration for processing aqueous product solutions in lignocellulosic biorefineries
Technical University Berlin

Pouresmaeil, Shabnam
Bioelectrochemical power-to-gas using bed electrodes based on biochar
University of Leipzig

Prempeh, Clement Owusu
Generation of silicon dioxide from biogenic residues for advanced applications
University of Rostock/
University of Stellenbosch, South Africa

Pujan, Robert
Systematic modelling of biorefinery processes
Norwegian University of Science and Technology

Reinelt, Torsten
Monitoring of locally unknown and time-varying methane emissions from biogas plants
Technical University Dresden

Richter, Lukas
Optimised energy management in an energy cell
Pending approval

Richter, Sören
Development of bioeconomy scenarios until 2050
University of Leipzig

Röder, Lilli Sophia
Implementation of demand-side management in biorefineries
Ruhr University Bochum

Schliermann, Thomas
Synthesis and property optimisation of biogenic silica through thermochemical conversion on the basis of rice husks in conversion plants from a laboratory to kg scale
Pending approval

Siol, Christoph
Assessing new technologies for the circular bioeconomy with combined environmental and economic LCSA
University of Leipzig

Sumfleth, Beike
Assessment of low indirect land use change risk indicators in the sustainability certification of biobased products
University of Leipzig

Thiel, Christian
Reduction of volatile organic compounds (VOCs), soot, polycyclic aromatic hydrocarbons (PAHs) and particulates in a single-room stove
Pending approval

Undiandeye, Jerome Anguel
Fermentation of agricultural residues for energetic and material utilisation
University of Rostock

Wedwitschka, Harald
Development of a method for feedstock characterisation for box fermentation processes
University of Rostock

Zerback, Timo Rolf
Effects of hydrothermal substrate disintegration in the biogas process
Pending approval

List of current dissertations in cooperation with the Helmholtz Centre for Environmental Research GmbH – UFZ

(As of 1 February 2022)
*Successful completion in 2021/2022

Baleeiro, Flávio César Freire
A biorefinery on sugarcane by-products based on the carboxylate and syngas platforms
Karlsruhe Institute of Technology

Chan, Katrina
Modelling of energetic and material biomass use in sustainable agriculture and food scenarios
University of Leipzig

Cheng, Zhe
Fate and effects of antibiotics in anaerobic digestion systems
Technical University Berlin

Grosch Schröder, Bruna
Development of a biogas production process inspired by the Pachnoda marginata larvae gut system
University of Leipzig

Jordan*, Matthias
The future role of bioenergy in the German heat sector: Insights from an energy system analysis
University of Leipzig

Jusakulvijit, Piradee
Sustainable bioethanol development for an approach to circular economy in Thailand – an evaluation by multi-criteria decision making
University of Leipzig

Kähl, Daniel
Reduction of the inhibitory effects of propionic and butyric acid in methanation by promoting direct interspecies electron transfer
University of Leipzig

Logroño, Washington
Flexible alkalitolerant biomethanation of renewable hydrogen derived from excess electricity
University of Leipzig

Musonda, Frazer
Modelling of Bioenergy and bioeconomy futures: The optimal allocation of biomass to competing sectors
University of Leipzig

Schäfer, Christina
Engineering microbial communities for the conversion of lignocellulose into medium-chain carboxylates
University of Leipzig

Tafarte*, Philip
Assessing the potential of immediate technical options for an optimized renewable energy supply – a case study for Germany
University of Leipzig

Zeug, Walter
A holistic life cycle sustainability assessment for bioeconomy regions – linking regional assessments, stakeholders and global goals
University of Leipzig

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“I’m doing my doctorate at the DBFZ because I’m interested in future-oriented topics. At the same time I want to put my acquired knowledge to practical use!”

7 Science Communication

How can current research topics in the field of bioenergy and the bioeconomy be communicated in a comprehensible way to the DBFZ's various target groups? This was again the focus of the DBFZ's science communication in 2021. In addition to producing a wide range of scientific publications and press and media work, the DBFZ's event management team was once again able to organise a large number of virtual, hybrid and face-to-face events. Since 2021, one particular aim has been to further expand project-related science communication.

Press and media work

DBFZ scientists were repeatedly in demand in 2021 as experts on a variety of bioenergy and bioeconomy-related research topics. For example, scientific assessments of various research topics were provided for the TV programmes "MDR Wissen", "ARD plusminus" and "Quer" (BR). The DBFZ contributed to various media reports (TV/print/online) on subjects such the avoidance of harmful emissions from wood-burning stoves and the use of straw for energy. The DBFZ also issued political position papers, for example on the possible conversion of coal-fired power plants to biomass. Deputy Scientific Managing Director Daniela Thrän was once again a sought-after

DBFZ research was showcased in the following media (a selection):

- Leipziger Volkszeitung
- MDR Wissen
- ARD plusminus
- Agrarzeitung
- NDR
- TopAgrar
- Holz-Zentralblatt
- Tagesspiegel
- Bayerischer Rundfunk
- Welt
- Deutschlandfunk
- VDI-Nachrichten
- Energie und Management

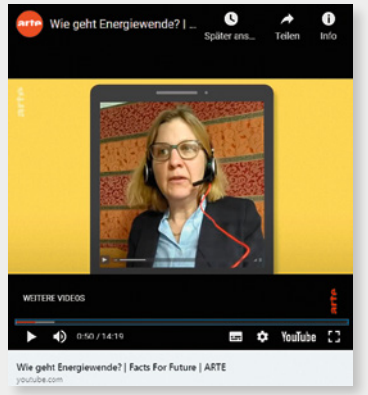

Fig. 27: Prof. Dr. Daniela Thrän at "Facts for Future" (arte)

Fig. 28: MDR films at the biorefinery lab and the DBFZ research biogas plant

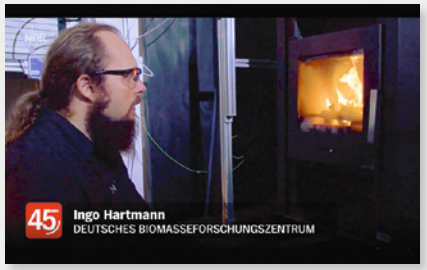

Fig. 29: Scientist Prof. Dr. Ingo Hartmann (Thermo-chemical Conversion Department) in the NDR report “Fireplaces: Cosy, but harmful?”

interviewee on topics such as the bioeconomy and the renewable energy transition.

Press and media relations is taking increased advantage of the use of social media. Event content, (open access) publications, press releases, job advertisements and project results are regularly published on the DBFZ’s social media channels LinkedIn, Twitter and XING. In addition, more and more science topics and presentations were published on Youtube in 2021. Interested in staying up to date on bioenergy and the bioeconomy? Follow us on social media.

New publications (DBFZ publications series)

Five new issues of the DBFZ publication series “DBFZ Report” were published in 2021. These include the dissertation papers “Optimised control strategies for pellet-solar combisystems to increase system efficiency while minimising energy costs”, “Contribution to optimising the pelleting behaviour of fermentation residues and landscape hay and their blends” and “National resource monitoring for biogenic residues, by-products and wastes – development of a systematic data collection, management and assessment for Germany”. Other publication issues covered the “Basics of anaerobic digestion – biochemical conversion and process modelling” and the “Framework conditions for optimised operation of small biomass-based CHPs”. These and other DBFZ publications (see table) can be download for free from the DBFZ’s website.

The accompanying research of the BMWK’s bioenergy research program and network also produced new publications as part of the publication series in 2021. The publications, which are also available free of charge, include a booklet on the topic of “Bioenergy in the electricity and heat market (project results 2019–2020)”, two conference readers, and the methods manual “Material flow-oriented balancing of climate gas effects”.

Fig. 30: Dissertations published as part of the publication series “DBFZ Report”

Tab. 6: Overview of publications published in 2021 (series and brochures)

Publication Series “DBFZ Report”

Report No. 39 “Optimised control strategies for pellet-solar combisystems to increase system efficiency while minimising energy costs” (Dissertation)
ISBN 978-3-946629-67-2

Report No. 40 “Basics of Anaerobic Digestion – Biochemical Conversion and Process Modelling”
ISBN 978-3-946629-72-6

Report No. 41 “National Resource Monitoring for Biogenic Residues, By-products and Wastes – Development of a Systematic Data Collection, Management and Assessment for Germany” (Dissertation)
ISBN 978-3-946629-74-0

Report No. 42 “Framework Conditions for Optimised Operation of Small Biomass-Based CHPs”
ISBN 978-3-946629-75-7

Report No. 43 “Contribution to Optimising the Pelleting Behaviour of Fermentation Residues and Landscape Hay and their Blends" (Dissertation)
ISBN 978-3-946629-76-4

Publication Series “DBFZ Conference Reader”

Conference Reader “12th Expert Discussion on Particle Separators in domestic furnaces”
ISBN 978-3-946629-70-2

Conference Reader “4th Doctoral Colloquium BIOENERGY”
ISBN 978-3-946629-77-1

Brochures

Brochure “Biomass expertise for the EU Green Deal”

Brochure “Guidance on Calculating Greenhouse Gases from Energy Produced from Biogas and Biomethane for Sustainability Certification under the RED II”
ISBN 978-3-946629-79-5

DBFZ Jahresbericht 2020
ISBN 978-3-946629-52-8

DBFZ Annual Report 2020
ISBN 978-3-946629-55-9

Publication Series “Bioenergy research program”

Booklet “Bioenergy in the Electricity and Heating Market (Project Results for 2019–2020)”
ISBN 978-3-946629-71-9

Publication series: Method Handbook “Material Flow Oriented Balancing of Climate Gas Effects” (2021)
ISBN 978-3-946629-58-0

Conference Reader “10th Status Conference 2021: Bioenergy – a Partner for Every Case”
ISBN 978-3-946629-78-8

Conference Reader “5th CMP International Conference on Monitoring & Process Control of Anaerobic Digestion Processes”
ISBN 978-3-946629-68-9

→ **Further information and free downloads:**
www.dbfz.de/en/reports
www.dbfz.de/en/tagungsreader
www.energetische-biomassenutzung.de/en/publications

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Events hosted by and with the DBFZ

Due to Corona, events in 2021 were once again mainly held virtually. The DBFZ hosted and co-hosted a large number of events in various formats throughout the year. Highlights included the 4th Doctoral Colloquium BIOENERGY (see page 74), the 12th Expert Discussion on “Particle separators in domestic furnaces” and virtual participation in major public events such as the “Long Night of the Sciences” and “Environment Week” under the patronage of Germany’s President Frank Walter Steinmeier.

A look back at events in 2021

For the 12th time, the Expert Discussion “Particle separators in domestic furnaces” took place as a virtual event on 4 February 2021 in proven partnership with the Technology and Support Centre (TFZ). The expert discussion showed once again in 2021 that there is a variety of new technical solutions, developments and installation variants in the field of dust separators. The Blue Angel for Wood-Burning Stoves, which was introduced at the end of 2019, has led the industry to step up its efforts in achieving clean air. As a result, ambitious “zero-emission” targets are gaining in importance. A new record of 142 participants from Germany, Austria and Switzerland was set. The conference reader for the event can be downloaded for free from the DBFZ’s website.

From 10 to 11 June, the DBFZ was an exhibitor for the second year at the “Week of the Environment”, presenting its research topic “Low-emission log firing for coupled electricity and heat generation in existing housing stock”.

Fig. 31: “Green Carbon Cycle” Industry Meeting (20 October 2021)

On 16 July 2021 the DBFZ also took part in the “Long Night of the Sciences” in Leipzig, providing various videos and holding virtual lectures. Other highlights included the “Green Carbon Cycle” Industry Meeting organised jointly with BioEconomy e. V. on 20 October and the biofuel expert discussion on “Advanced Biomethane as Fuel”, which took place as an online event at the DBFZ on 16 November.

Fig. 32: Video presented by the DBFZ at the Long Night of the Sciences 2021

Save the date: DBFZ Annual Conference 2022

Everyone is talking about the European Green Deal, but how can it be made a reality? What exciting ideas can practitioners build on to create sustainable innovations and how can policy support this? The theme of the DBFZ’s 2022 Annual Conference is “The Green Deal & beyond – the contribution of biomass-based research and innovation”. The Annual Conference offers the opportunity to explore these questions and actively participate in shaping the answers. Breaking with tradition, the DBFZ’s Annual Conference will no longer be held in autumn, but in spring. We would like to invite you to take part in the annual conference from 21 to 23 June 2022 to exchange views on current research topics and to network with a wide range of experts from research, business and politics. Those who cannot attend in person in Leipzig will have the opportunity to stream selected events. The DBFZ’s Annual Conference is aimed at researchers studying bioenergy and the bioeconomy, decision-makers from the agricultural, energy and environmental sectors, experts from regional and national companies, as well as associations and societies in the energy sector. We look forward to your attendance!

2022 DBFZ ANNUAL CONFERENCE

→ **Further information:**
www.bioenergiekonferenz.de

A highlight of events in 2022

9 February 2022
Expert Discussion on Biogas in Leipzig:
“The ageing of biogas plant components”

10 February 2022
13th Expert Discussion “Particle separators in domestic furnaces”

9–12 May 2022
European Biomass Conference and Exhibition (EUBCE)

11/12 May 2022
15th BIOGAS Innovation Congress

16/17 June 2022
16th Rostock Bioenergy Forum

21–23 June 2022
DBFZ Annual Conference
“Green Deal & beyond – the contribution of biomass-based research and innovation”

13/14 September 2022
5th Doctoral Colloquium BIOENERGY

27/28 September 2022
7th HTP Expert Forum
“Hydrothermal Processes”

Expected in Autumn 2022
Expert Discussion on Biofuels in Leipzig

November 2022
Expert Discussion on Biogas in Leipzig

Fig. 33: The DBFZ event team

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8 International Activities

One of the DBFZ's key objectives is to participate in international (non-European) scientific projects so that its scientific expertise can be made available to foreign partners. This involves participating in joint research projects, doctoral student exchanges and reciprocal research stays. Another goal is to establish cooperation with international universities and research institutes and to consolidate and selectively expand international networks. This also includes initiating and arranging reciprocal visits and organising workshops and conferences. Despite the ongoing global pandemic, its international activities continued to expand in 2021, especially on the topic of soil improvement.

Fig. 34: DBFZ's joint projects outside Europe

Fig. 35: Smallholder farming in the Oromia region of Ethiopia

ETH-SOIL – Soil improvement project launched in Ethiopia

The African country of Ethiopia has made significant developmental progress over the past two decades. However, food insecurity and malnutrition, which are caused, among other things, by increasing soil degradation, hinder sustainable economic growth. The situation is further aggravated by current political conflicts and unrest. The "ETH-Soil" project, which began in June 2021, aims to significantly improve food security in three Ethiopian pilot areas in the Oromia region through the utilisation of an organic fertiliser from pyrolysis and biogas plants. Biochar is combined with fermentation residues from biogas plants or compost material to create a fertiliser for soil improvement so that the advantages of both feedstocks can be used effectively. An important factor in ensuring sustainability is the participatory technological development of pyrolysis cookers as well as training and further education modules. Using this approach, the project is making a significant contribution to the national implementation of the 2030 Agenda. The project is dedicated to combating hunger through untapped agricultural and social potentials, the sustainable management of natural resources, and education and training to foster economic, social and technical progress. The project will run from 2021–2026.

→ **Further information:**
www.eth-soil.com

"The ETH-Soil project is a important project for my country. The Ethiopian people are using biomass for cooking by cutting down trees, which causes a lot of environmental destruction like soil erosion. Once this project improves the soil, I am sure that people will experience a better harvest or will be able to farm. We will benefit greatly from this."

H. E. Mulu Solomon Bezuneh
(Ethiopian Ambassador)

A life cycle assessment of the provision of soil improving agents in India/ Benin/Madagascar

The development of sustainable agricultural cultivation systems poses a major challenge in light of the globally increasing demands on ecosystem services. A key aspect here is to secure long-term soil fertility and health while at the same time taking into account various utilisation demands such as nutrition, preservation of biodiversity, etc. The development of sustainable agricultural systems is a major challenge. The German Society for International Cooperation (GIZ) is working with regional partners to develop various solutions for preserving soil fertility in regions in Benin, India and Madagascar. Among other things, residual and waste materials are processed into soil improving agents and integrated into the regional agricultural management systems on site. The products and technologies include biochar, Bio PROM (phosphate rich organic manure), compost, digestate from biogas production, and residues from sugar cane processing.

The DBFZ supports the GIZ and its regional partners in this process by analysing the environmental impacts of the production of these soil improving agents. These include emissions resulting from the use of energy during processing as well as direct process emissions (e. g., from composting). Based on the results of these assessments, the processes and value chains for the production of soil improving agents are being optimised together with the GIZ and regional partners so that the processes can be made even more sustainable in the future. One of the DBFZ's main tasks will be to collect the data on the region-specific technology and logistics together with regional partners. To this end, a series of workshops and interviews will take place in spring 2022 to collect data. The project was launched in December 2021 and will run until the end of 2022.

Study on the feasibility of in-situ extraction of biogenic silica from rice husks in the Mekong Delta

Vietnam is the world's fifth largest rice producer, producing 44 million tonnes annually (2018)[8]. In the Mekong Delta alone, over 24 million tonnes of paddy rice are harvested annually. When processed into white rice, 17 to 20 per cent of the total mass of the rice husks is a by-product. Due to their high content of biogenic silica and very low nutritional value[9], rice husks are not a source of nutrients and can therefore be put to alternative use. Rice husks are commonly used to generate heat when wet-harvested rice is dried[10]. Comparatively simple batch dryers are used. From a resource efficiency perspective, however, the heat generated by the current technology is largely wasted and the husk ash is often not disposed of properly.

At the end of September 2021, the project "MekongSi" (P3110043) started focusing on the feasibility of extracting biogenic silica with a combined heat use from rice husks in the Mekong Delta (inhouse, GIZ/Vietnam). Partners in Vietnam are the International Rice Institute (IRRI) and the GIZ. Information on the potential of rice husks and their current use is to be gathered through a market survey, and the market potential of biogenic silica is to be explored. Tied to this is a resource screening of the quantities of rice husks produced in the Mekong Delta region and at the paddy rice production sites. Alongside the preparation of an economic feasibility study, a process will be designed and adapted at a representative rice mill in the Mekong Delta for the coupled material and energy use of biogenic silica with heat utilisation for drying processes. The DBFZ will receive 60,000 euros for the study, which will run until the end of July 2022.

[8] FAO
[9] 7th NDDB Report 2012
[10] Nguyen-Van-Hung, Tran-Van-Tuan, Pyseth Meas, Caesar Joventino M. Tado, Myo Aung Kyaw & Martin Gummert (2018): Best practices for paddy drying: case studies in Vietnam, Cambodia, Philippines, and Myanmar, Plant Production Science.

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Fig. 36: Biogenic silica can be obtained from the husks of the rice plant.

→ **Further information:**
www.dbfz.de/en/research/international-activities

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9 Knowledge and Technology Transfer

The DBFZ conducts research for a climate-neutral society of the future. One of the key objectives of its knowledge and technology transfer is to communicate its R&D results to policymakers, industry and civil society so these results can be put to use.

Knowledge Transfer

The aim of knowledge transfer is to impart scientific findings to a specific social target group so that the best possible, scientifically sound decision can be made given the situation. The DBFZ uses a variety of formats and channels to do this. Policy advice (see page 101) has played a prominent role in this for many years. The use of data products to transfer knowledge will likely become even more important in the coming years.

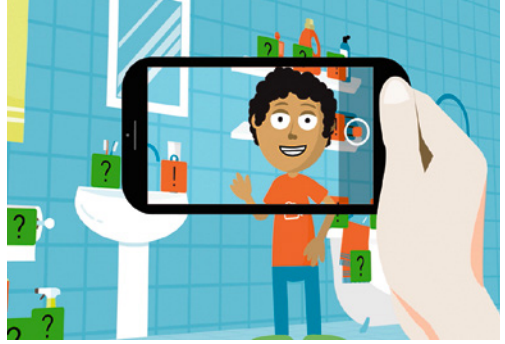
Technology Transfer

The aim of technology transfer is to bring innovations to market or to shorten innovation cycles. The DBFZ offers extensive technical support in the development of new or the improvement of existing technologies, services and business models. The DBFZ's outstanding research infrastructure (laboratories, pilot plants and experimental facilities) is geared towards practical application and, as part of collaborations and service contracts, offers an excellent platform for small, medium and large companies from a range of sectors – from agriculture and forestry, to plant and equipment construction, and the food, paper/pulp and chemical industries. Many solutions have been developed and much information has been made available which can be incorporated into industrial process chains or corporate decision-making through active technology transfer.

→ **Further information:**
www.dbfz.de/en/services

Video-challenge „SogehtBiö“

As part of the video challenge “SogehtBiö” (This is how the bioeconomy works), young people between the ages of 13 and 19 were called upon to point out what the bioeconomy means/can mean for them in their everyday lives. As part of the competition, which ran from 1 May to 31 August 2021, the students created films on one of several topics. Their films were then evaluated by an interdisciplinary jury. During the competition, various scientific partners, including the DBFZ, provided the young people with expert advice. Funded by the Federal Ministry of Education and Research as part of the Science Year 2020/2021, the challenge gave participants the opportunity to deal intensively through the videos, and in some cases for the first time, with the term bioeconomy, to express their view of a sustainable world, and to provide ideas for possible changes. Along the way, they learned how to prepare a filming schedule and edit a video.



© EPC mbH

Fig. 37: Video challenge “How does the bioeconomy relate to my everyday life?”

→ **Further information:**
www.sogehtbiooekonomie.de

High-performance biolubricants from insect fat

The DBFZ is continuing its successful research on insect biomass in close cooperation with industry as part of its “BioLube” project. The project aims to produce high-performance, industry-scale lubricants made from black soldier fly fat and to make insect feeding particularly sustainable, i. e., residue based. Since the start of the project in spring 2021, various feeding trials have been carried out using different substances. The different types of feed have been analysed in order to generate the first comparable and thus transferable results. Legal hurdles are a limiting factor here, as the same rules apply to insects as to other livestock: many residues that originate from agriculture but come from other sectors in later processing steps cannot be used as feed. The initial results of the feed analyses have been positive. In 2022, the focus will be on developing the lubricant together with its industry partners Hermetia Baruth GmbH, Danico Biotech GmbH and Pilot Pflanzenöl Magdeburg e. V. (PPM). Other interested companies may be involved in later phases of the project. The project, which is funded by the BMBF’s funding programme “SME-innovative”, will run until April 2024.

© Hermetia Baruth GmbH

Fig. 38: Mating black soldier flies

→ **Further information:**
www.dbfz.de/en/biolube

9.1 Policy Advice

Research into the sustainable use of biomass as a material and energy source encompasses a range of different topics and levels of investigation. These must be regularly brought together and investigated to provide targeted support for decision-makers in politics and industry. To this end, the DBFZ offers ministerial policymakers, political parties, associations, and the specialist public a wide range of advisory services in the areas of bioenergy and the bioeconomy. These services take the form of statements, background papers and recommendations on current legislative projects, amendments to and adaptations of laws and strategy processes and replies to ministerial or parliamentary enquiries. Or the services are offered in the context of lectures and expert discussions. Research findings form the basis of this alongside the continuous observation of the development of the (bio)energy markets and their political framework conditions, the monitoring of projects in the areas of electricity generation from biomass and the use of biofuels, as well as energy system scenarios for the medium and long-term use of biomass in the energy sectors.

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The focus of policy advice in 2021

Despite the amendment to the EEG, which was completed at the turn of 2021, the promotion of renewable energies in the electricity sector remained a focus of scientific policy advice in 2021. The DBFZ provided support on issues relating to the approval of the EEG by the European Commission under state aid law, on the cost-efficient design of a follow-up subsidy for plants that use a high proportion of farm manure, and on improvements to the flexibility surcharge for existing biomass plants. Other areas of focus domestically included the further development of the greenhouse gas reduction quota in the transport sector (a topic on which the DBFZ, represented by Dr. Franziska Müller-Langer as Head of Biorefineries Department, advised the German Bundestag), the production of hydrogen from and with biomass, and the possible conversion of coal-fired power plants to ones based on biomass.

In the second half of the year, focus was on the classification and evaluation of proposals by the European Commission as part of the "Fit for 55" package: in addition to the planned amendment of the Renewable Energies Directive (RED II), this included the revision of the Energy Tax Directive (ETD) and the ensuing consequences for the national taxation of biofuels and energy sources for heat applications. Other topics included VAT tax cuts for firewood, emissions from wood combustion, and the possible use of wood ash in the cement industry. Further knowledge transfer took place – largely virtually due to the pandemic – within the framework of various events, such as the Climate Protection Action Alliance or the Biogas Annual Conference as part of the dena Energy Transition Congress.

Since January 2017, the DBFZ has been advising the German government on an ongoing basis by sending staff directly to the Federal Ministry of Food and Agriculture (BMEL). The aim is to provide content-related support to Department 524 "Energy Affairs, Bioenergy".

An overview of the policy advisory services

_ Scientific monitoring of legislative and administrative law-making procedures
_ Support in developing political strategies in the areas of bioenergy/bioeconomy
_ Monitoring and impact assessment of legislation
_ Analysis of the bioeconomy's framework conditions for policies on climate, energy, the environment and research

→ **Further information:**
www.dbfz.de/en/services/policy-recommendations-and-advice
www.dbfz.de/en/press-media-library/more-publishments/statements-studies

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Fig. 39: DBFZ position papers from 2021

Tab. 7: A selection of activities and positions in 2021

Topic	Addressed to
Position paper on the conversion of coal-fired power plants	Politics, ministries, expert public
Background paper on the greenhouse gas reduction quota	Expert public
Recommendations in the context of the EEG 2021	BMEL, BMWi, EEG Clearing House
Background paper "Hydrogen from and with Biomass"	PtJ, BMWi
Commenting on the EU Commission's "Fit for 55" package	BMEL

9.2 Science-Based Services

As a research institute that predominantly focuses on applied research, the DBFZ co-operates closely with project partners from industry and therefore offers extensive contract research as well as a wide range of science-based and technical services. These go beyond the main research areas and are aimed equally at politics, industry, associations, experts and committees. The work is implemented in an interdisciplinary and cross-departmental manner to fully utilise the expertise of the DBFZ in a comprehensive and efficient manner as part of the following advisory and technical services.

Science-based services

_ Market analyses and data provision
_ Technical, economic and ecological evaluation
_ Concept and process development and optimisation
_ Scientific support of R&D projects

→ **Further information:**
www.dbfz.de/en/services/science-based-services


a


b

The DBFZ has an analytical laboratory as well as offering a special R&D infrastructure in the three technical research areas of biochemical conversion, thermo-chemical conversion and biorefineries. Its technical and scientific services are aimed at plant and mechanical engineering, process developers, plant operators and other R&D companies and institutions.

Technical and scientific services

Biochemical Conversion Department:

_ Market analysis (based on the annual operator survey, among other things), forecasting and strategy consulting
_ Scientific support for the development of plant components
_ Assessment of processes with regard to efficiency, technical feasibility and the economy
_ Testing (batch and continuous testing, microbial electrochemical tests)
_ Concept development for specific site conditions
_ Biogas process analysis
_ Determination of energy quantities (electricity, heat) and identification of optimisation potentials

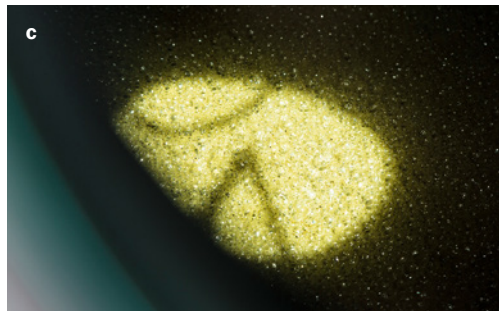
Thermo-chemical Conversion Department:

_ Development, characterisation, pre-treatment and additivation of fuels
_ Combustion tests and comparative classification of combustion properties
_ Separator measurement of dust and CO measurements
_ CFD simulation of thermodynamic processes
_ Investigation of catalyst technology for combustion integration
_ Catalyst investigations on the test bed and in practice with regard to efficiency and emissions
_ Catalyst screening in model gas and real gas
_ Catalyst characterisation by physisorption and chemisorption measurements
_ Catalyst synthesis
_ Innovative concept development for integrated renewable heat systems

Biorefineries Department:

Pilot plant trials on:
_ Hydrothermal carbonisation and liquefaction
_ Fixed-bed and dust gasification
_ Synthesis gas process
_ Gas purification
_ Solid-liquid/liquid-liquid separation processes for biogenic recyclables from aqueous media

Fig. 40 a–c: The DBFZ offers a wide range of technical and scientific services.


c

Analytical lab

In order to assess the potential uses of various biomasses, the DBFZ's analytical laboratory investigates the chemical composition and fuel properties of solid biofuels, biogas substrates, liquid fuels, by-products from agriculture and forestry and other biogenic residues and waste materials, as well as their conversion products such as ash, filter dust, HTC coal and process water. The analysis is carried out according to current standards and using problem-oriented method development or adaptation. The following parameters can be determined using the available equipment: pellet density, bulk density, particle size distribution, percentage of fines, abrasion resistance, calorific value, water content, volatile content, various carbon species, CHNS composition, ash content, elemental composition with regard to major and trace elements, total content of sulphur and chlorine as well as concentrations of elutable components, density, viscosity, refractive index, flash point, degree of copper corrosion, acid and saponification number for glycerol as well as the pH value. Fatty acid methyl esters (FAMEs) and phenols can be identified and quantified by GC analyses and the concentrations of sugars and furan derivatives can be determined by HPLC. In the future, a method for determining volatile organic or polycyclic aromatic hydrocarbons (BTEX or PAH) by GC will be established. The use of an accelerated solvent extraction (ASE) for sample preparation is also planned, the methods of which are still under development.

→ **Further information:**
www.dbfz.de/en/services/technical-and-scientific-services

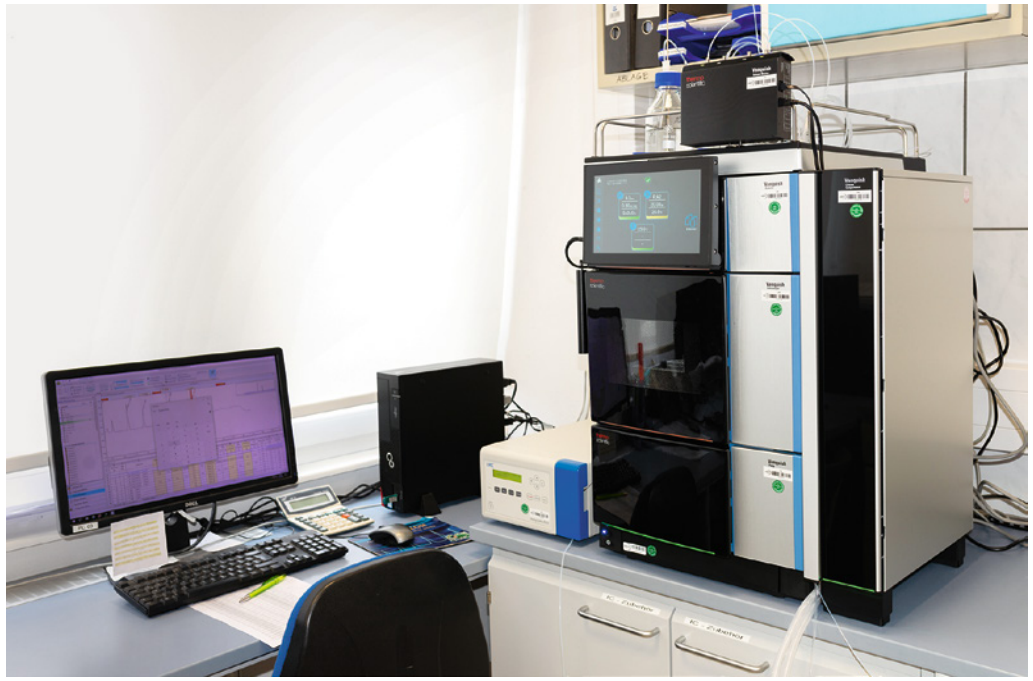


Fig. 41: New HPLC system in the DBFZ's analytical lab

Fig. 42: New stamp briquetting machine in the DBFZ's technical centre

Research infrastructure

Tab. 8: Overview of the points of contact in the DBFZ's laboratories, test beds and technical facilities

Department	Description	Point of Contact
Biochemical Conversion Department	Research biogas plant	Ulf Müller E-mail: ulf.mueller@dbfz.de Christian Krebs E-mail: christian.krebs@dbfz.de
	Biogas lab	Dr. Liane Müller E-mail: liane.mueller@dbfz.de Katrin Strach E-mail: katrin.strach@dbfz.de
	Emission measurement	Lukas Knoll E-mail: lukas.knoll@dbfz.de
Thermo-chemical Conversion Department	Combustion lab	Michael Junold E-mail: michael.junold@dbfz.de
	Fuel conditioning lab	Dr. Claudia Kirsten E-mail: claudia.kirsten@dbfz.de
Biorefineries Department	Biorefineries technical centre	André Hermann E-mail: andre.herrmann@dbfz.de
Bioenergy Systems Department	Databases/research data	Dr. Kai Radtke E-mail: kai.radtke@dbfz.de
	Assessment methods	Stefan Majer E-mail: stefan.majer@dbfz.de
	Potential analyses	Dr. Friederike Nageli de Torres E-mail: friederike.naegeli@dbfz.de
All departments	Analytical lab	Igor Adolf E-mail: igor.adolf@dbfz.de

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10 Networks/ Research Alliances

The DBFZ is a member of numerous networks and research alliances related to the bioeconomy and bioenergy. Strong networking within the national and international research landscape and with industry is essential in order to solve the complex challenges of the energy and raw material transition in a comprehensive and sustainable way.

IEA Bioenergy

The IEA Bioenergy is an organisation founded in 1978 by the International Energy Agency (IEA) with the aim of improving international cooperation and the exchange of information on bioenergy research. Members of the IEA Bioenergy working groups (tasks) number approximately 200 scientists from OECD and non-OECD countries who come together for three-year work programmes. In the triennium 2019–2021, DBFZ scientists participated in five of the eleven tasks. The highlights of 2021 included numerous reports and publications (country reports, open access articles, etc.) with DBFZ authorship. In December 2021, the DBFZ gave two presentations at the final conference of the 2019–2021 triennium "Bioenergy's contribution to low-carbon energy systems". In the new 2022–2024 triennium, the DBFZ will continue to participate – either through joint leadership or active collaboration – in Tasks 37, 39, 40, 44 & 45.

→ **Further information:**
www.dbfz.de/en/iea-bioenergy

© IEA Bioenergy

Fig. 43: The IEA Bioenergy Triennial Conference's session on "Bioenergy's contribution to low-carbon energy systems" (7 December 2021)

EERA Bioenergy

As a full member of the European Energy Research Alliance (EERA) since 2019, the DBFZ has represented various aspects of bioenergy in five subgroups of the EERA Bioenergy programme. The overall goal of EERA Bioenergy is to evolve into a robust research and development tool to assess the research challenges and priorities of bioenergy as set out in the European Union's Strategic Energy Technology Plan (SET-Plan) roadmap. By joining the European Energy Research Alliance, the DBFZ has become even more closely involved in European bioenergy research. Its membership augments the portfolio of the EERA with the know-how of the "Smart Bioenergy" approach developed by the DBFZ.

Further activities take place within the following networks, predominantly with a focus on an exchange between science, industry and administration:

_ Renewable Energy Research Association – FVEE
_ BioEconomy Cluster
_ BMWK bioenergy research program and network
_ The Energy Saxony energy cluster
_ Network for Energy and Environmental Technology Leipzig – NEU e. V.
_ TREC Danube Network (EU level)

Scientific cooperation with universities and research institutes

Scientific cooperation with universities and other research institutions is another essential component of the DBFZ's networking activities. The focus of its activities here is on implementing the defined research goals as part of applied research and development (R&D). There has been a long-standing cooperation with the Helmholtz Centre for Environmental Research – UFZ on issues relating to the system assessment of bioenergy and the microbiological foundations of biochemical processes. Here, the DBFZ's research focus area "Bioenergy Systems" works closely with the UFZ's "Bioenergy" Department (headed in both cases by Professor Dr. Daniela Thrän). At the same time, the research department "Biochemical Conversion" cooperates with the UFZ's Microbiology Department "MicAS". In the area of energy recovery from organic waste and residual materials, there is also a strategically oriented cooperation between the DBFZ research focus areas and the Rostock Chair of Waste and Material Flow Management (ASW), represented by the scientific managing director of the DBFZ, Prof. Dr. Michael Nelles. The DBFZ and the University of Rostock are co-hosts of the annual Rostock Bioenergy Forum.

Since the end of 2011, the DBFZ's deputy scientific managing director, Prof. Dr. Daniela Thrän, has worked closely with the University of Leipzig through the Chair of Bioenergy Systems at the Faculty of Economics (IIRM – Institute for Infrastructure and Resource Management). DBFZ scientists also teach at the University of Leipzig and at national universities such as Chemnitz University of Technology, Dresden University of Technology, Anhalt University of Applied Sciences, Merseburg University of Applied Sciences and Leipzig University of Applied Sciences. Since winter semester 2020/2021, Prof. Dr. Ingo Hartmann (head of the research focus area "Catalytic Emission Control" at the DBFZ) has also been representing the "Special Areas of Environmental Engineering III" module at the Leipzig University of Applied Sciences (HTWK) as an honorary professor for air pollution control technology. In addition, scientific cooperation with non-European countries, especially China, has been greatly expanded in recent years. DBFZ scientists are active as visiting professors at Hefei University and other renowned universities in China.

11 Committee Activities

DBFZ scientists act as experts for a wide range of scientific bodies, advisory boards, working groups, networks and committees, and are (visiting) professors in Germany and abroad. The aim of their committee work is to achieve an intensive exchange with the scientific community.

Scientific Committees/Executive Boards/Directorates (a selection)

Tab. 9: Selected committee activities of DBFZ staff (as of February 2021)

Committee	Function	Country	Since
Advisory Board of the Aviation Initiative for Renewable Energy in Germany e. V. (aireg)	Member of the Executive Board	Germany	2011
Association for the Promotion of Exhaust Aftertreatment Technologies for Combustion Engines (FAD)	Member of the Advisory Board	Germany	2013
Association of German Engineers (VDI), Mecklenburg-Western Pomerania District Association	Board member	Germany	2008
Biomass to Power and Heat	Member of the Programme Committee	Germany	2014
Bioeconomy Council – independent advisory body for the federal government	Co-chair	Germany	2021
BioEconomy Cluster of BioEconomy e. V.	Member of the Executive Board	Germany	2012
German Association for Waste Management e. V. (DGAW)	Member of the Executive Board	Germany	2014
German Bioenergy Association (BBE)	Member of the Advisory Board	Germany	2012
German-Chinese Centre in Anhui Province	Member of the Executive Board	China	2009
Sino-German Centre for Environmental Technology & Knowledge Transfer (CETK) of Anhui Province	Director	China	2005
Circular Economy 4 Africa	Member of the Executive Board	Germany	2020
Doctoral Colloquium BIOENERGY	Member of the Programme Advisory Board	Germany	2018
Doctoral Colloquium BIOENERGY	Member of the Scientific Advisory Board	Germany	2018
Energy and Environment Foundation Leipzig	Member of the Board of Trustees	Germany	2013
Energy and Climate Protection Advisory Council of the Saxon State Ministry for Energy, Climate Protection, Environment and Agriculture (SMEKUL)	Member	Germany	2021

Committee	Function	Country	Since
European Biogas Association (EBA)	Member of the Scientific Advisory Board	Belgium	2019
Export initiative RETech “Recycling & Waste Management in Germany” of the German Federal Government (BMUV, BMWK, BMZ)	Member of the Board and Head of the China Working Group	Germany	2014
Helmholtz Centre for Environmental Research – UFZ	Member of the Scientific Advisory Board	Germany	2013
IEA Bioenergy, Task 37 “Energy from Biogas”	Member	International	2019
IEA Bioenergy, Task 39 “Commercialising Conventional and Advanced Transport Biofuels from Biomass and Other Renewable Feedstocks”	National team leader	International	2014
IEA Bioenergy, Task 40 “Deployment of Biobased Value Chains”	Co-task leader, national team leader	International	2019
IEA Bioenergy, Task 44 “Flexible Bioenergy and System Integration”	Co-task leader, national team leader	International	2019
IEA Bioenergy, Task 45 “Climate and Sustainability Effects of Bioenergy within the Broader Bioeconomy”	National team leader	International	2019
Institute for Non-Classical Chemistry e. V. at the University of Leipzig (INC)	Member of the Advisory Board	Germany	2013
IUTA e. V. – Project Accompanying Committee: Multiphase anode materials for SOFC – Development of effective catalyst systems based on cerium oxide for the upgrading of biogas and biomethane (KatCe). biogas and biomethane (KatCe)	Member of the Advisory Board	Germany	2014
LaNDER3–Hochschule Zittau/Görlitz	Member of the Advisory Board	Germany	2017
Mecklenburg-Western Pomerania State Energy Council	Member and Chair of the F&L Working Group	Germany	2012
Ministry of Agriculture, Environment and Consumer Protection Mecklenburg-Western Pomerania	Member of the Scientific Advisory Board	Germany	2017
Renewable Energies Research Association (FVEE)	Member of the Executive Board	Germany	2015
Renewable Energies Research Association (FVEE)	Bioenergy expert (electricity, heat, fuels) and FVEE spokesperson 2021	Germany	2016
Renewable Energies Research Association (FVEE) Annual Conference	Member of the scientific management	Germany	2022
Renewable Energies Research Association (FVEE) Annual Conference	Member of the Programme Committee	Germany	2016
Research Steering Committee of the Federal Ministry of Food and Agriculture (BMEL)	Member	Germany	2012
Scientific journal “Müll & Abfall”	Member of the Advisory Board	Germany	2007
Strategy Council for Economy and Science Mecklenburg-Western Pomerania	Spokesperson of the Future Energy Field	Germany	2014
Thuringian Ministry for the Environment, Energy and Nature Conservation	Member of the Scientific Advisory Board for Climate Protection and Climate Impact Adaptation	Germany	2019
verbio Biofuel and Technology “Straw in the Tank” Conferences	Member of the Scientific Advisory Board	Germany	2017

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Fig. 44: The Bioeconomy Council of the Federal Government with Co-Chair Prof. Dr. Daniela Thrän (centre)

Professorships

Institution	Function	Country	Since
Faculty of Agricultural and Environmental Sciences, University of Rostock	Professorship	Germany	2006
Faculty of Energy and Environmental Science, Shenyang Aviation University	Professorship	China	2011
Faculty of Environmental and Biotechnology, Hefei University	Professorship	China	2002
Faculty of Environmental and Biotechnology, Hefei University	Professorship	China	2018
Institute for Infrastructure and Resource Management, Chair of Bioenergy Systems, University of Leipzig	Professorship	Germany	2011
Institute for Renewable Energy, Petroleum University Beijing	Professorship	China	2014
University of Applied Sciences, Leipzig	Professorship	Germany	2020

Working Groups

Committee	Function	Country	Since
Agru Interlaboratory Test, Board of Trustees for Technology and Building in Agriculture (KTBL)	Member	Germany	2018
Bioeconomy WG of the Structure-Related Commission on Technology Assessment and Design (Saxon Academy of Sciences in Leipzig)	Member	Germany	2020
BMDV Working Group 2 – Alternative Drives and Fuels for Sustainable Mobility	Member	Germany	2019
BMWK Bioenergy Research Network, WG Electricity/WG Heat	Member/Expert	Germany	2017
BMWK Bioenergy Research Network, Harmonisation of Methods	Head	Germany	2010
BMWK Bioenergy Research Network, Harmonisation of Methods	Member/Coordinator	Germany	2010

DECHEMA
Gesellschaft für Chemische Technik und Biotechnologie e.V.

ETIP Bioenergy
European Technology and Innovation Platform

Committee	Function	Country	Since
BMWK Dialogue Platform “Industrial Bioeconomy”, WG 4 “Communication”	Member	Germany	2021
BMWK/PTJ bioenergy research program and network	Deputy WG Leader	Germany	2019
DECHEMA		Germany	
Expert Group “Industrial Use of Renewable Resources”	Member		2020
Expert Group “Measurement and Control in Biotechnology”	Member		2018
ProcessNet–Sustainable Production, Energy and Resources (SuPER), “Alternative Fuels and Combustibles”*	Member		2015
ProcessNet–Sustainable Production, Energy and Resources (SuPER), “Energy Process Engineering”	Member		2014
EERA Bioenergy;		EU/Belgium	
Subprogramme			
1: Sustainable production of biomass	Member		2019
2: Thermochemical platform	Member		2019
3: Biochemical platform	Member		2019
4: Stationary bioenergy	Member		2019
5: Sustainability/Techno-economic analysis/ Public acceptance	Member		2019
European Biofuels Technology Platform (ETIP Bioenergy)		EU/Belgium	
WG1 Biomass Availability	Member		2007
WG4 Policy and Sustainability	Member		2008
German RETech Partnership “Recycling & Waste Management in Germany”	Member of the International Working Group (Emerging and Developing Countries)	Germany	2017
Project Group on Russia of the City of Leipzig	Member	Germany	2020
RHC–European Technology and Innovation Platform on Renewable Heating and Cooling		Belgium	
Horizontal Working Group: 100 % RE Individually Heated & Cooled Buildings	Member		2019
Horizontal Working Group: 100 % RE Cities	Member		2019
WG Biogas of VGB PowerTech e. V.	Member	Germany	2019
WG “Energy”, Board of Trustees for Technology and Building in Agriculture (KTBL)	Member	Germany	2019
WG Heat Market 2.0			
WG “Library concepts” of the BMEL departmental research institutions	Member	Germany	2016
WG on Substance-Specific Waste Treatment (ASA) e. V.	Member of the Advisory Board	Germany	2009
WG “OpenAgrar” of the BMEL departmental research institutions	Member	Germany	2016

* ProcessNet is an initiative of Dechema and VDI-GVC

Networks/Associations/Platforms (a selection)

Committee	Function	Country	Since
BioEconomy e. V.	Member	Germany	2012
BioWEconomy of the European Commission	Member Core Group/ Initiators	EU/Belgium	2020
BMDV National Platform “Future of Mobility”, WG 2 – Alternative drives and fuels for sustainable mobility	Member	Germany	2019
Committee on the Sustainability of Biofuels and Bioliquids of the European Commission	Member	EU/Belgium	2017
DENA (German Energy Agency) Biogas partner – the platform for biogas feed-in	Member	Germany	2017
DFBEW German-French Office for the Energy Transition	Member	Germany/France	2016
Energy Committee of the Leipzig Chamber of Industry and Commerce (IHK)	Member	Germany	2016
Expert Panel of Energy Saxony e. V.	Member	Germany	2013
Förderverband Humus e. V. (FVH)	Member of the Scientific Advisory Board	Germany	2019
Network Energy and Environment e. V. (NEU e. V.) – Bioenergy Cluster	Member of the Advisory Board	Germany	2014
Network for Carbon Cycle Economy (NK2)	Member	Germany	2019
PREVENT Waste Alliance	Member	Germany	2020
Sustainable Development Solutions Network (SDSN) of the German Development Institute	Member of the Extended Steering Committee	Germany	2016

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BioEconomy Cluster

Mitglied bei PREVENT Abfall Allianz

DIN/ISO – Standard Committees (a selection)

Committee	Function	Country	Since
Association of German Engineers e. V. (VDI)		Germany	
_ VDI 3670 “Flue gas cleaning – downstream dust abatement equipment for small combustion plants for solid fuels”	Chairman		2014
_ VDI 3670: Flue gas cleaning – downstream dust abatement equipment for small combustion plants for solid fuels”	Member		2014
_ VDI 4630 “Fermentation of organic substances – substrate characterisation, sampling, substance data collection, fermentation tests”	Member of the Policy Committee		2019
CEN–European Committee for Standardization TC 454 Algae and algae products	Chairman of WG 3 “Productivity”	Belgium	2015
German Institute for Standardisation e. V. (DIN)		Germany	
_ Working Committee “Requirements for liquid fuels” NA 062-06-32 AA	Member		2020
_ Working Committee “Liquefied gases, requirements and testing” NA 062-06-31 AA	Member		2021
_ Working Group “Dust separator testing” DIN 33999	Member		2012
_ Working Committee “Biogas” NA 032-03-08 AA	Member		2015
_ Working Committee “Pyrogenic carbon” na 062-02-85 aa NA 062-02-85 AA	Chairwoman		2021
_ Working Committee “Biogenic solid fuels” NA 062-05-82 AA	Member		2019
International Organization for Standardization (ISO)		Switzerland	
_ ISO TC 238 Solid Biofuels WG 1 “Terminology”	Convenor		2022
_ ISO TC 238 Solid Biofuels WG 2 “Fuel specifications and classes”	Task leader		2020
_ ISO TC 238 Solid Biofuels WG 7 “Safety of solid biofuels”	Member		2019
_ ISO/TC 238 Task Group 1 “Biochar”	Member		2021
_ ISO TC 255 Biogas WG 1 “Terms, definitions and classification scheme for the production, conditioning and utilization of biogas”	Member		2015
VDI/DIN Commission on Air Pollution Control (KRdL)		Germany	
_ WG 3933 “Production of biomass carbonisates”	Member		2013
_ Committee for Basic Guidelines “Bioeconomy, biological transformation – terms, methods, definitions”	Contributors		2021
_ Guideline Preparation Committee VDI 3475 Sheet 8, “Emission Reduction; Digestate Treatment Plants”	Chairman		2021
_ Guideline Preparation Committee VDI 3475 Sheet 9 “Emission Reduction; Manure Processing Plants”	Chairman		2021

12 Structure and Organisation

In order to handle the diverse range of research tasks, an organisational structure comprising four research departments has been established at the DBFZ. These research departments cooperate closely with each other. While the Biochemical Conversion, Thermo-chemical Conversion and Biorefineries departments mainly work on applied research tasks in the field of bioenergy and the bioeconomy, the Bioenergy Systems Department develops policy recommendations, provides advice, conducts potential analyses and acceptance studies, and creates various scenarios for biomass use and database-based web applications.

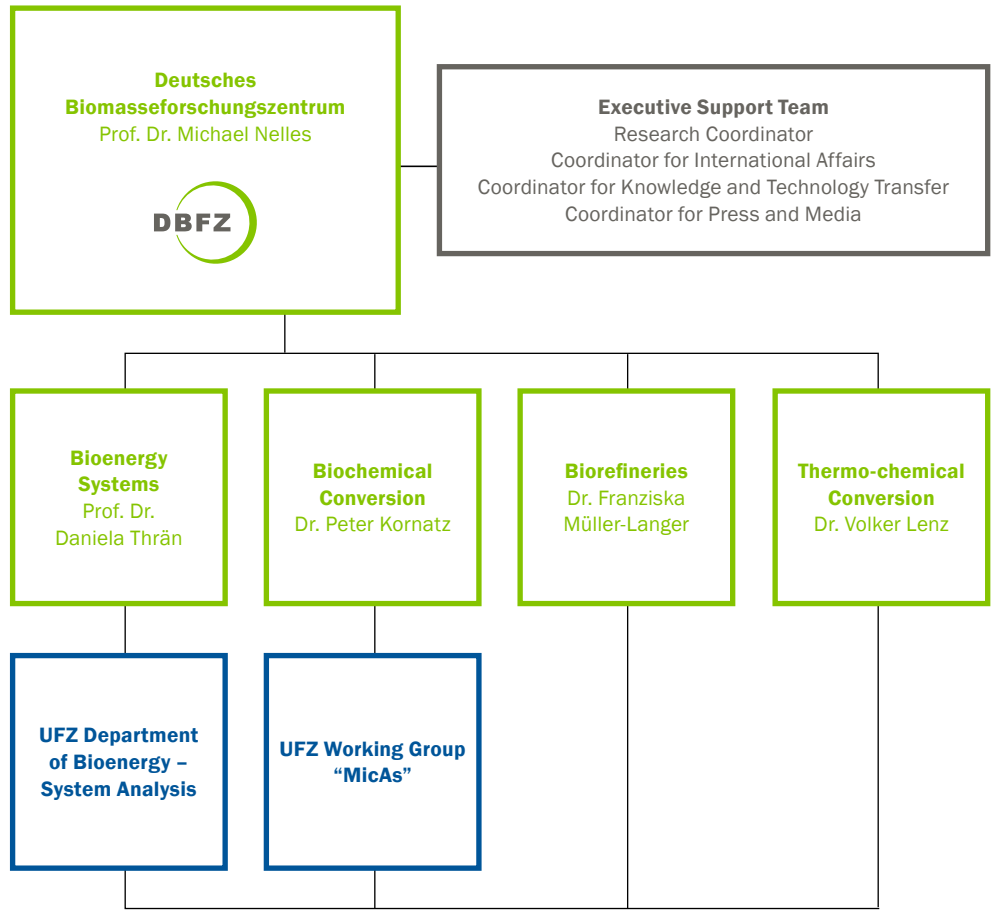

Fig. 45: The four research departments of the DBFZ, the executive support team, and the two departments that cooperate with the Helmholtz Centre for Environmental Research (UFZ)

12.1 Supervisory Board/ Research Advisory Council

Supervisory Board

The Supervisory Board, which is chaired by the Federal Ministry of Food and Agriculture (BMEL), makes the substantive and organisational decisions regarding the development of the DBFZ. Other members are the Federal Ministry of Education and Research (BMBF), the Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV), the Federal Ministry for Digital and Transport (BMDV), the Federal Ministry for Economic Affairs and Climate Action (BMWK) and the Saxon State Ministry for Energy, Climate Protection, Environment and Agriculture (SMEKUL). The Supervisory Board meets twice a year at the DBFZ.

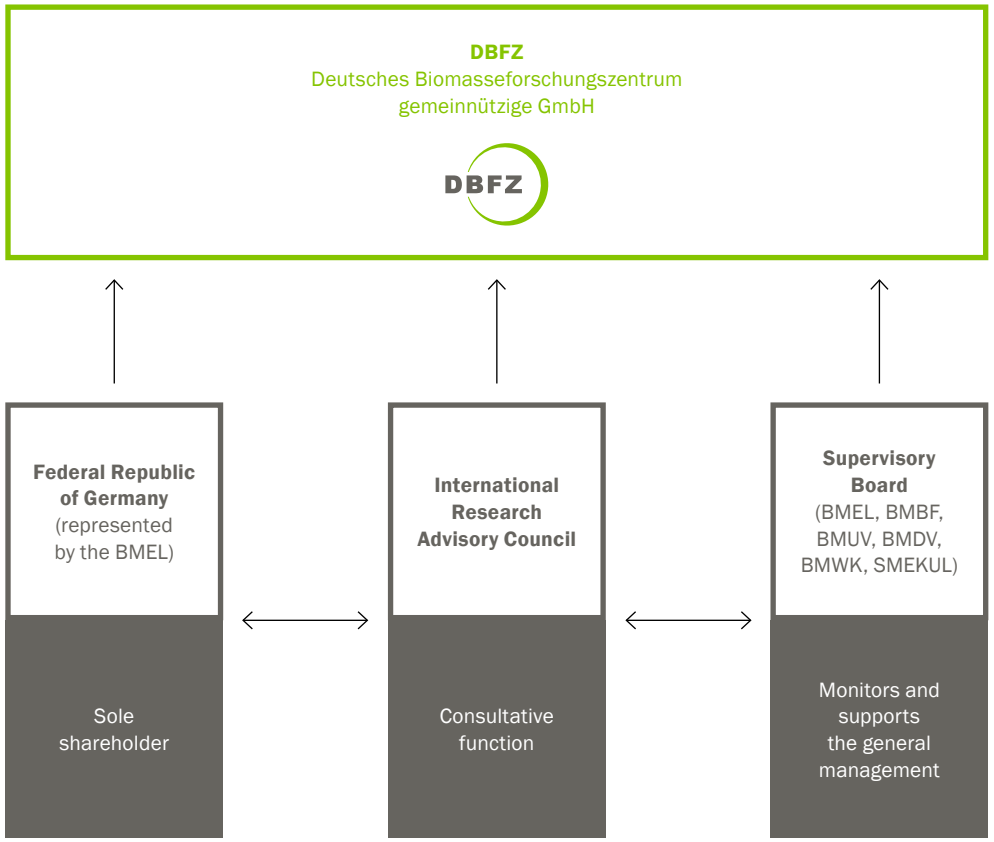

Fig. 46: The supervisory bodies of the DBFZ (as of February 2022)

The representatives of the Supervisory Board are as follows:

(as of 28 February 2022)
* Retired as of 28 February 2022

Olaf Schäfer (Chair)
Ministerial Director
Head of Subdepartment 52 “Sustainability, Renewable Resources and Biodiversity”,
Federal Ministry of Food and Agriculture (BMEL)

Berthold Goeke (Deputy Chair)*
Ministerial Director
Head of Subdepartment “KI I Climate Protection Policy”,
Federal Ministry for the Environment, Nature Conservation, Nuclear Safety and Consumer Protection (BMUV)

Daniel Gellner
Head of Department 3 “Agriculture and Forestry”,
Saxon State Ministry for Energy, Climate Protection, Environment and Agriculture (SMEKUL)

Dr. Christine Falken-Großer
Head of Division IIA2 “Bilateral Energy Policy Cooperation”,
Federal Ministry for Economic Affairs and Climate Action (BMWK)

Dr. Kerstin Zimmermann
Senior Government Councillor, Department 7 (Provision for the Future),
Unit 722 “Energy, Hydrogen Technologies”
Federal Ministry of Education and Research (BMBF)

Birgit Breitfuß-Renner
Ministerial Director
Subdepartment G2, “Environment and Noise Protection”
Federal Ministry for Digital and Transport (BMDV)






Fig. 47: The Supervisory Board of the DBFZ

Research Advisory Council

The Research Advisory Council (RAC), made up of nationally and internationally renowned bioenergy experts, has been advising the DBFZ on the direction of its scientific activities since its foundation in 2008. The recommendations of the Advisory Council ensures that the research carried out with institutional funding is scientifically sound and highly relevant for the current and future use of bioenergy in the energy system. The term of the current board runs from 2020 to 2023.

Tab. 8: Representatives of the Research Advisory Council are as follows (as of February 1, 2022)

Council Member	Organisation	City and Country
Chiaramonti, Prof. Dr. David	Polytechnic University of Turin – DENERG – Department of Energy "Galileo Ferraris"; RE-CORD – Renewable Energy Consortium for Research and Demonstration	Turin (Italy)
Dong, Prof. Dr. Renjie (Deputy chair)	China Agricultural University (CAU) – National Center for International Research of BioEnergy, Science and Technology	Beijing (China)
Dornack, Prof. Dr. Christina (Chair)	Technical University Dresden – Institute of Waste Management and the Circular Economy	Dresden (Germany)
Grzybek*, Prof. Dr. habil. Teresa	AGH University of Science and Technology Kraków – Department of Fuel Technology	Krakow (Poland)
Hartmann, Dr. Hans	Technology and Support Centre (TFZ) at the Competence Centre for Renewable Resources	Straubing (Germany)
Kemfert, Prof. Dr. Claudia	German Institute for Economic Research (DIW Berlin)	Berlin (Germany)
Murphy, Prof. Dr. Jerry	University College Cork – Professorship of Civil Engineering	Cork (Ireland)
Schenk, Prof. Dr. Joachim	Leipzig University of Applied Sciences – Chair of Environmental Engineering	Leipzig (Germany)
Teutsch, Prof. Dr. Georg	Helmholtz Centre for Environmental Research – UFZ	Leipzig (Germany)
Thiffault, PhD Evelyne	Laval University – Department of Wood and Forest Sciences	Québec (Canada)
Wagemann, Prof. Dr. Kurt	DECHEMA – Society for Chemical Engineering and Biotechnology	Frankfurt/Main (Germany)
Walter, Prof. Dr. Arnaldo	University of Campinas – Department of Energy	Campinas (Brazil)

Fig. 48: Meeting of the Research Advisory Council at the DBFZ (19 October 2021)

Fig. 49: Members of the Research Advisory Council in the DBFZ Biogas Lab

12.2 Finances/Third-Party Funds

The DBFZ was founded in 2008 as a limited liability company (GmbH). It is an institutional funding recipient in the Federal Ministry of Food and Agriculture's (BMEL) business unit and is recognised as a non-profit organisation in accordance with Section 52 (2) No. 1 of the German Fiscal Code (AO). Its aim is to make flexible and transparent use of public research funding and to be able to carry out research and advisory work on behalf of third parties. The DBFZ is financed through institutional shortfall funding from the Federal Ministry of Food and Agriculture as well as through competitively acquired project grants, contract research and services. In 2021, the DBFZ received funding from the BMEL amounting to € 19.4 million. An additional € 12.9 million in third-party funding was also raised (see Figure 50). Personnel costs constituted the primary expenditures at € 13.6 million. Other expenditures included approx. € 5.2 million for investments and € 6.9 million for material expenditures.

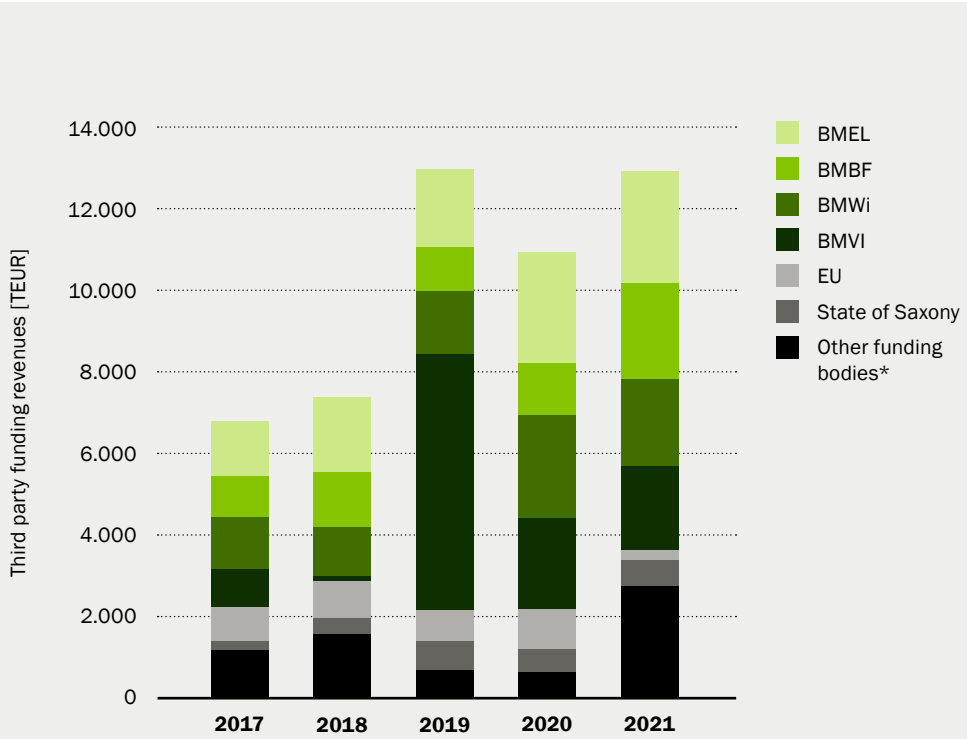

Fig. 50: Overview of third-party funding revenue from 2017–2021 (preliminary figures)
* Contract research and services from private and public clients

12.3 Personnel/Training

As of 31 December 2021, 265 people were employed at the DBFZ. Of these, 206 people (incl. the Executive Support Team) were employed in scientific/technical areas and 59 in administration (including the Infrastructure and Property Management Department and IT). In 2021, a large number of research work was again supervised at the DBFZ. A total of 23 internships and student research projects as well as 49 bachelor's, master's and diploma dissertations were professionally supervised. In addition, a total of 31 guest researchers, foreign interns and scholarship holders worked at the DBFZ.

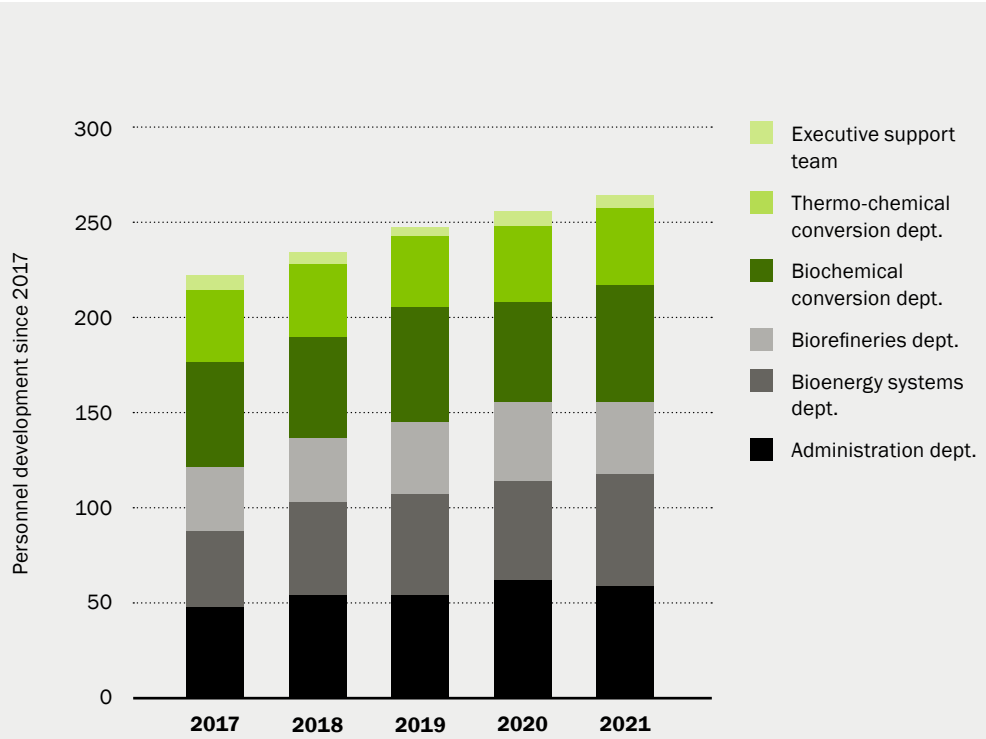

Fig. 51: Personnel development at the DBFZ (2017–2021)

Employees according to departments

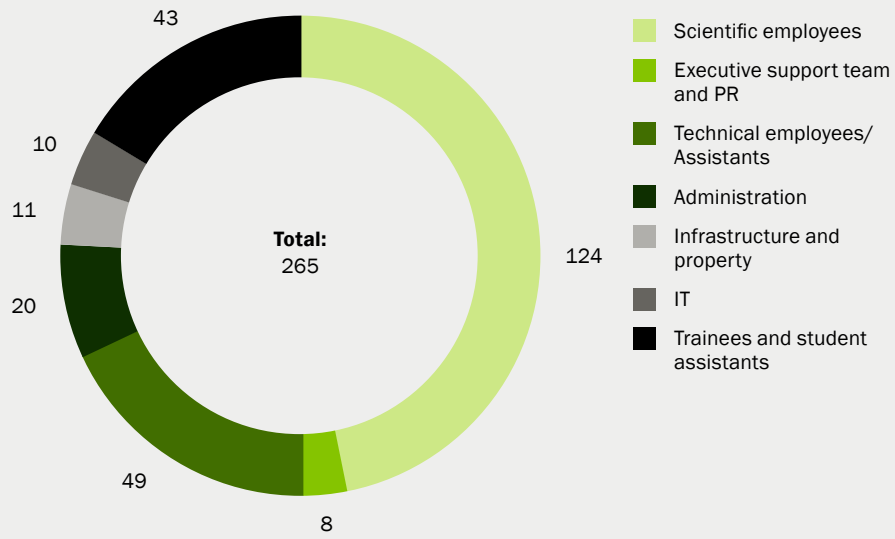

Fig. 52: Number of employees by area (as of 31 December 2021)

Supervised work at the DBFZ

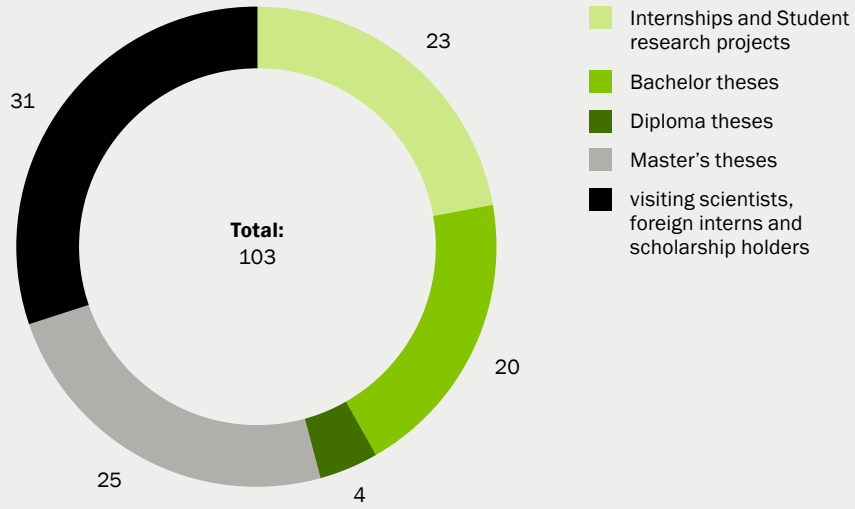

Fig. 53: Overview of the work supervised at the DBFZ in 2021 (as of 31 December 2021)

Trainees at the DBFZ

The DBFZ has been a training company since it was founded in 2008. By the end of 2021, a total of 34 trainees and retrainees had successfully completed their training. In 2021, there were 13 trainees/retrainees looking to become either an "event management assistant", "office management assistant", "electronics technician for industrial engineering", "chemical laboratory assistant" and "mechatronics technician" (m/f/d), as well as seven BA students studying "information technology", "controlling", "environmental technology" and "laboratory and process technology".

"I am very happy that I was able to successfully complete my training as a mechatronics technician at the DBFZ in January 2022 despite the corona pandemic."

Sebastian Völker

An interview with trainee Sina Braune

Abb. 54: Trainee Sina Braune

Ms Braune, you have been a trainee in the DBFZ's Administration Department since 1 August 2021. What are you currently doing?

SINA BRAUNE: I am currently stationed in the accounts department and am learning about various accounting processes, including archiving. As part of my training, I work in various administrative departments, including purchasing. However, I am particularly interested in the work that is done in the management's office. Here, I can do the kind of tasks I enjoy the most: booking hotels, providing support for business trips, and being in contact with people outside the institute. This is right down my alley. But the tasks in the other departments are also a lot of fun, of course.

How did you find out about the DBFZ and what excites you about research?

SINA BRAUNE: I found the DBFZ on the internet. Last year I did a lot of research about becoming an office management assistant and quickly came across the DBFZ. I personally find research to be exciting, particularly because the research that is done here relates very specifically to the environment. This is an important topic and concerns us all. It's good to work at an institute that conducts research in this area.

To what extent do you have contact with the other trainees at the DBFZ?

SINA BRAUNE: There are currently 13 trainees working here and we meet up from time to time. It's always exciting for me to find out how things are going in the other areas, for example with the technical trainees, who have a completely different syllabus to me. From the beginning, I found it important to be able to exchange ideas with other trainees, like if something didn't go so well.

Do you already have an idea about what you want to do after your training?

SINA BRAUNE: My training at the DBFZ will last another two and a half years. I would like to stay here afterwards and use the knowledge I have acquired to work in administration. Of course, I would also like to further develop my skills and become proficient in more complex tasks. If the DBFZ doesn't work out, I would also be interested in the healthcare sector. But to be honest, I haven't thought that much about it yet.

→ **Further information (in German):**
www.dbfz.de/karriere/ausbildung/duales-studium

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13 Appendix: Projects and Publications

Major projects and publications from 2021 are listed below to illustrate the current working areas of the DBFZ. The language of the title reflects the language of the project/publication. The ministries are listed according to their designations prior to the 2021 federal election and have been retained accordingly for this annual report.

Projects (a selection)

Federal Ministry of Food and Agriculture (BMEL)

A+BiOx – Thermo-chemical conversion of silicon rich biomass residues for the production of heat and power, and the combined generation of mesoporous biogenic silica for material application, Bundesministerium für Ernährung und Landwirtschaft, 1.1.2020–31.12.2022 (FKZ: 2819D0KA05)

BIO2HY – Wasserstoff aus Biomasse, Bundesministerium für Ernährung und Landwirtschaft, 1.4.2021–31.12.2021

BioHum – Klimaschutzorientierte Bioabfallverwertung in der Landwirtschaft (KlimaBioHum), Bundesministerium für Ernährung und Landwirtschaft, 1.10.2018–31.5.2022 (FKZ: 281B303316)

BioSim – Nachwuchsforschergruppe zur modellbasierten Zustandsüberwachung und Prozessführung an Biogasanlagen, Bundesministerium für Ernährung und Landwirtschaft, 1.11.2020–31.10.2023 (FKZ: 2219NR333)

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HTCGas – Vergasung von HTC-Kohle, Bundesministerium für Ernährung und Landwirtschaft, 1.7.2021–31.3.2022

HypoBio – Entwicklung einer effizienten und emissionsarmen, kleinen Scheitholzfeuerung mittels kontinuierlicher Brennstoffzuführung, Bundesministerium für Ernährung und Landwirtschaft, 1.8.2020–31.7.2022 (FKZ: 2219NR273)

IE-BioNetz – Integration und Bewertung regenerativer Energien in bestehenden Wärmenetzen und dezentralen Wärmeversorgungskonzepten, 1.02.2019 – 30.09.2021 (FKZ: 22405317)

IRASIL – Untersuchung des Ascheverhaltens während der thermo-chemischen Konversion vorbehandelter, siliziumreicher Biomassesortimente zur Strom- und Wärmeerzeugung und Nutzung der dabei anfallenden Aschen zur Gewinnung anorganischer Gerüstverbindungen mit vielfältigen Anwendungsmöglichkeiten, Bundesministerium für Ernährung und Landwirtschaft, 1.1.2018–30.6.2021 (FKZ: 2816D0KI03)

MEMO – Methanemissionsmodell für offene Gärprodukt-/Güllelager (MEMO), Bundesministerium für Ernährung und Landwirtschaft, 1.11.2021–31.10.2024 (FKZ: 2220WD003X)

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MoBi_II – Aufbau eines systematischen Monitorings der Bioökonomie – Konsolidierungsphase; Teilvorhaben 2: Aktualisierung Reststoffmonitoring, Bundesministerium für Ernährung und Landwirtschaft, 1.11.2021–31.10.2024

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Nred – Verstärkte Nutzung stickstoffreicher landwirtschaftlicher Abfallstoffe durch biologische Stickstoffreduzierung (Nred), Bundesministerium für Ernährung und Landwirtschaft, 1.11.2019–31.10.2022 (FKZ: 22042118)

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OptiFlex – Optimierung des Betriebs und Design von Biogasanlagen für eine bedarfsgerechte, flexibilisierte und effiziente Biogasproduktion unter Berücksichtigung der Prozessstabilität als Post-EEG Strategie, Bundesministerium für Ernährung und Landwirtschaft, 1.10.2017–30.6.2021 (FKZ: 22401717)

PaplGas – Biomethan & Torfersatzstoff aus Pappelholz, Bundesministerium für Ernährung und Landwirtschaft, 1.4.2019–30.6.2021 (FKZ: 22038318)

PaplGas2 – Biomethan & Torfersatzstoff aus Pappelholz – 2. Phase, Bundesministerium für Ernährung und Landwirtschaft, 1.12.2021–30.11.2023 (FKZ: 2221MT017A)

RestFlex – Eignung landwirtschaftlicher Reststoffe zur Flexibilisierung des Biogasprozesses, Bundesministerium für Ernährung und Landwirtschaft, 1.7.2019–30.6.2022 (FKZ: 22041818)

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SiTroFen – Entwicklung einer emissionsarmen Einzelraumfeuerung für bedarfsgerecht erzeugte und qualitätsgesicherte Holzhackschnitzel, Bundesministerium für Ernährung und Landwirtschaft, 1.4.2019–31.12.2021 (FKZ: 22016817)

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VABIFEX – Wertoptimierte Nutzung von Biomasse in einer flexiblen Energieinfrastruktur; Teilvorhaben 1: Theoretische und experimentelle Untersuchungen, Bundesministerium für Ernährung und Landwirtschaft, 1.9.2018 – 31.07.2021 (FKZ: 22408317)

Federal Ministry of Education and Research (BMBF)

abonoCAR – WK abonoCARE – TP 2.V – Entwicklung der säure- und membranbasierten Phosphorabscheidung während der HTC sowie der energieeffizienten Trocknung von HTC-Kohle im Labormaßstab, Bundesministerium für Bildung und Forschung, 1.4.2019–31.12.2022 (FKZ: 03WKDI2E)

BOGOTA-1 – Vorstudie zur Erarbeitung eines Abfallbehandlungskonzeptes für die Stadt Bogotá/Kolumbien, Deutsche Gesellschaft für Internationale Zusammenarbeit GmbH, 1.12.2020–31.1.2022 (FKZ: 81264100)

CarBiPho – Entwicklung eines integrierten Verfahrens zur Carbonisierung von Klärschlamm, Erzeugung von Biogas und Rückgewinnung von Phosphor, Bundesministerium für Bildung und Forschung, 1.7.2018–30.06.2021 (FKZ: 02WQ1438B)

H2Mech – Machbarkeitsstudie zur biobasierten Wasserstoffherstellung – Abfallwirtschaftszentrum Mechernich, Bundesministerium für Bildung und Forschung, 1.10.2021–30.9.2022

HemiFuel – IBÖ-08: HemiFuel – Simultane Herstellung von 2-Methylfuran in Lignocellulose-Ethanolanlagen: Entwicklung eines hydrothermalen Verfahrensansatzes zur Verwertung der Hemicellulose, Bundesministerium für Bildung und Forschung, 1.10.2021–30.9.2022 (FKZ: 031B1190)

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Symobio+ – Systemisches Monitoring der Bioökonomie – TP DBFZ, Bundesministerium für Bildung und Forschung, 1.9.2020–31.8.2021 (FKZ: 031B0281J)

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Federal Ministry of Transport and Digital Infrastructure (BMVI)

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PILOT-SBG – Forschungs- und Demonstrationsvorhaben „Bioressourcen und Wasserstoff zu Methan als Kraftstoff – Konzeptionierung und Realisierung einer Anlage im Pilotmaßstab“, Bundesministerium für Verkehr und digitale Infrastruktur, 1.11.2018–31.12.2022

Federal Ministry for Economic Affairs and Energy (BMWi)

AbfallE – Abfall-Ende-Eigenschaft unbehandelter holzartiger Reststoffe durch Aufbereitungsverfahren und Qualitätssicherung, Bundesministerium für Wirtschaft und Energie, 1.11.2019–30.4.2022 (FKZ: 03KB160A)

BeForce – Begleitforschung Bioenergie, Bundesministerium für Wirtschaft und Energie, 1.4.2021–31.3.2025 (FKZ: 03EI5400)

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NormAKr – Normung alternativer Kraftstoffe, Bundesministerium für Wirtschaft und Energie, 1.1.2020–31.12.2022 (FKZ: 03EIV241C)
OBEN – Öl-Ersatz Biomasse Heizung, Bundesministerium für Wirtschaft und Energie, 01.09.2019–28.2.2023 (FKZ: 03KB156)
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OpToKNuS – Entwicklung einer „Toolbox“, basierend auf numerischen Modellen und Praxismessungen zur Auslegung bzw. Optimierung von thermochemischen Anlagen zur Energiebereitstellung aus alternativen Brennstoffen, Teilvorhaben: Untersuchung am DBFZ-Festbettlaborvergaser, 01.01.2020–31.12.2022 (FKZ: 03KB163B)
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CAFIPLA – (Carboxylic Acid & FIbre PLAtform) – Pretreatment of organic waste for application of the carboxylic acid and fiber platform, European Commission, 1.6.2020–31.5.2023 (GA 887115)
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Service/Contract Research

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