BIOENERGY
DOC2020
3RD DOCTORAL
COLLOQUIUM BIOENERGY

3RD DOCTORAL COLLOQUIUM BIOENERGY

17TH/18TH SEPTEMBER, 2020

#DOC2020

WWW.DOC-BIOENERGY.DE

IMPRINT

Publisher:
Deutsches Biomasseforschungszentrum Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Straße 116
04347 Leipzig
Phone: +49 (0)341 2434-112
Fax: +49 (0)341 2434-133
info@dbfz.de

Funding:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages

Gefördert durch:
Bundesministerium für Ernährung und Landwirtschaft
aufgrund eines Beschlusses des Deutschen Bundestages

General Management:
Prof. Dr. Michael Nelles (Scientific Managing Director)
Daniel Mayer (Administrative Managing Director)

3RD DOCTORAL COLLOQUIUM BIOENERGY
17th/18th September, 2020
ISBN: 978-3-946629-60-3

Pictures: Unless otherwise noted: DBFZ. The rights for illustrations in the context of abstracts and presentations belong to the speaker.
Design: Stefanie Bader, Beate Kämpf, **DTP:** Beate Kämpf

3RD DOCTORAL COLLOQUIUM BIOENERGY

17th/18th September, 2020 | Leipzig: DBFZ, 2020

3RD DOCTORAL COLLOQUIUM BIOENERGY

INHALTSVERZEICHNIS

3RD DOCTORAL COLLOQUIUM BIOENERGY

PROGRAMME

SEPTEMBER 17TH, 2020

13:30 - 14:30	**Welcome** **Closing DBFZ annual conference** Prof. Dr. Michael Nelles (Deutsches Biomasseforschungszentrum) **Opening 3rd Doctoral Colloquium BIOENERGY** **Keynote: Towards a sustainable bioeconomy: challenges & perspectives** Prof. Dr. Daniela Thrän (Deutsches Biomasseforschungszentrum/ Helmholtz-Zentrum für Umweltforschung GmbH – UFZ / University Leipzig) **Bioenergy 2050 - Pictures of the future** Videostatements of the members of the programme committee: **Sustainable Resource Base:** Dr. Omar Hijazi (Technical University München) **System Analysis Bioenergy:** Dr. Ludger Eltrop (University Stuttgart) **Biochemical Conversion:** Dr. sc. agr. Hans Oechsner (University Hohenheim) **Thermochemical Conversion:** Dr. Kathrin Weber (SINTEF Energy Research) **Biorefineries:** Prof. Dr. Nicolaus Dahmen, Karlsruher Institute of Technology & Prof. Dr. Andrea Kruse (University Hohenheim)
14:30 - 15:20	**Coffee Break**
15:20 - 16:25	**Poster-Speedpresentation (parallel)** Session 1 | Sustainable Resource Base Session 2 | Bioenergy System Analysis

POSTER-SPEEDPRESENTATION (PARALLEL-SESSIONS)

15:20 - 16:25 SESSION 1
SUSTAINABLE RESOURCE BASE

Host: Dr. Omar Hijazi

1	**Biofuels from wastes in the marmara region, Turkey: Potentials and constraints** Ocak Semra (Boğaziçi University), Turkey
2	**National resource monitoring for biogenic residues, by-products and wastes – development of a systematic data collection, management and assessment for Germany** André Brosowski (Leipzig University / Deutsches Biomasseforschungszentrum), Germany
3	**A review on supply cost of biogenic resources in Europe** Tom Karras (Leipzig University / Deutsches Biomasseforschungszentrum), Germany
4	**Peat use reduction and biomass market in Germany** Olivier Hirschler (Johann Heinrich von Thünen-Institut/ Deutsches Biomasseforschungszentrum), Germany
5	**Making Sense of Global Future Storylines in the Perspective of Sustainable Bioeconomy Strategies** Seung Hye Lee (INSA - Institut National des Sciences Appliquées Toulouse), France
6	**Simultaneous carbon storage in arable land and anthropogenic products (CSAAP): demonstrating a new concept towards well below 2°C** Zhou Shen (INSA - Institut National des Sciences Appliquées Toulouse), France
7	**Response of soybean to bagasse-based ashes and thermochemical products as P-fertilizer in Oxisol soil** Vitalij Dombinov (Rheinische Friedrich-Wilhelms University Bonn / Forschungszentrum Jülich), Germany
8	**Investigation of heavy metal content in solid material at the cement plant that applies co-processing** Muhammad Angga Kusuma (University of Rostock), Germany

POSTER-SPEEDPRESENTATION (PARALLEL-SESSIONS)

15:20 - 16:25

SESSION 2
BIOENERGY SYSTEM ANALYSIS

Host: Prof. Dr. Daniela Thrän

1	**How bioenergy policy in Germany can be explained. A policy analysis of RED II, EEG and EEWärmeG** Katrin Beer (Otto von Guericke University Magdeburg), Germany
2	**Optimal biomass allocation to the German bio-economy based on conflicting economic and environmental objectives** Frazer Musonda (Leipzig University / Helmholtz-Centre for Environmental Research – UFZ), Germany
3	**Carbon capture readiness of German bioenergy plants: Retrofit criteria as tool for assessing nearterm potential for CO_2 utilization and storage** Alena Hahn (Leipzig University / Deutsches Biomasseforschungszentrum), Germany
4	**Hydrothermal Carbonization of biowaste – A proficient technology to reduce CO_2-emissions?** Felix Mayer (Cologne University of Technology), Germany
5	**Evaluation of political instruments regarding their potential to reduce regional nitrogen surpluses** Steffi Dietrich (Martin Luther University Halle-Wittenberg / Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) Müncheberg e.V / Deutsches Biomasseforschungszentrum), Germany
6	**Potential assessment of second-generation bioethanol development from agricultural residues in Thailand with participatory selection of sustainability criteria** Piradee Jusakulvijit (Leipzig University / Helmholtz Centre for Environmental Research – UFZ), Germany

ORAL PRESENTATIONS (PARALLEL-SESSIONS)

	SESSION 1 SUSTAINABLE RESOURCE BASE **Host: PD Dr. Kurt Möller, Dr. Omar Hijazi**	SESSION 2 BIOENERGY SYSTEM ANALYSIS **Host: Prof. Dr. Daniela Thrän, Dr. Ludger Eltrop**
16:30	**Sawmill by-products in a bioeconomy – Econometric analysis of price cointegration and value chain interlinkages** Marilene Fuhrmann (BOKU – University of Natural Resources and Life Sciences Vienna / BEST – Bioenergy and Sustainable Technologies GmbH), Austria	**Modeling the future use of bioenergy in the German heat sector, under consideration of consumer preferences** Matthias Jordan (University Leipzig / Helmholtz Centre for Environmental Research - UFZ), Germany
16:55	**Modelling and assessment of biomass resource in urban energy systems within the framework of the food-energy-water nexus** Keyu Bao (HFT Stuttgart - Stuttgart University of Applied Sciences / University Leipzig), Germany	**Advanced modular process analysis tool for biomass-based Chemical Looping systems GmbH** Thomas Steiner (Graz University of Technology / BEST - Bioenergy and Sustainable Technologies), Austria
17:20	**Considering the interaction between crop residues, bioeceonomy conversion pathways and the return of carbon to soils** Christhel Alejandra Andrade Díaz (INSA - Institut National des Sciences Apliquées), France	**Follow-up concepts for agricultural biogas plants – a techno-economic evaluation** Katharina Scherge (Leuphana University Lüneburg), Germany
17:45 - 18:10	**EU low iluc policy and certification** Beike Sumfleth (University Leipzig / Deutsches Biomasseforschungszentrum), Germany	**Development and Current Status of Solid Biofuel Markets in the European Union** Niels Kirstein (Deutsches Biomasseforschungszentrum), Germany
	Optional Networking-Session for questions & discussions to Session 1	**Optional Networking-Session for questions & discussion to Session 2**

SEPTEMBER 18TH, 2020

9:00 - 9:55	**Science communication via social media: Creating and communicating your own digital research profile** Dr. Ulrike Brandt-Bohne (Nawik - National Institute for Science Communication), Germany
10:00 - 11:00	**Poster-Speedpresentation (parallel)** Session 3 | Biochemical Conversion Session 4 |Thermochemical Conversion

POSTER-SPEEDPRESENTATION (PARALLEL-SESSIONS)

10:00 - 11:00 SESSION 3
BIOCHEMICAL CONVERSION

Host: Prof. Dr. Michael Nelles, Dr. Hans Oechsner

1	**Genome-resolved metagenomics sheds light on the anaerobic conversion of aromatics by complex communities** Felipe Borim Corrêa (Leipzig University), Germany
2	**Interaction between electroactive biofilms and anaerobic digestion effluents** Daniel Dzofou Ngoumelah (Leipzig University / Deutsches Biomasseforschungszentrum), Germany
3	**Biomethane potential of ensiled sugar beet leaves and cassava leaves** Jerome Undiandeye (University of Rostock / Deutsches Biomasseforschungszentrum), Germany
4	**Continuous anaerobic digestion of biowaste and co-substrates** Jan Sprafke (University of Rostock), Germany
5	**Flexible application of biogas upgrading membranes in power-to-methane processes** Andreas Gantenbein (EPFL - École polytechnique fédérale de Lausanne / PLI - Paul Scherer Institute), Switzerland
6	**Operational strategie for biogas plants with electricity and fuel supply** Fatih Gökgöz (University of Rostock / Deutsches Biomasseforschungszentrum), Germany
7	**Using Global X-Ray Tomography Data to Evaluate Local Optical Probe Measurements** Philipp Riechmann (PLI - Paul Scherer Institute), Switzerland

POSTER-SPEEDPRESENTATION (PARALLEL-SESSIONS)

10:00 - 11:00 PARALLEL-SESSION 4
THERMOCHEMICAL CONVERSION

Host: Prof. Dr. Peter Quicker

1	**Recycling of ashes from thermo-chemical conversion of agricultural residues** Thomas Schliermann (Deutsches Biomasseforschungszentrum), Germany
2	**Experimental and numerical investigation of a log wood stove** Andrea Dernbecher (Technical University of Berlin / Deutsches Biomasseforschungszentrum), Germany
3	**Development and application of novel SCR catalysts for the lowtemperature denitrification of exhaust gases from the thermo-chemical conversion of biogenic solid fuels** Mario König (Martin-Luther-University Halle-Wittenberg / Deutsches Biomasseforschungs-zentrum), Germany
4	**Ash-melting tendency of rice husk during combustion** Hossein Beidaghy Dizaji (Leipzig University / Deutsches Biomasseforschungszentrum), Germany
5	**Thermochemical conversion of agricultural residues for the generation of biogenic silica for mesoporous silicon carbide synthesis** Clement Owusu Prempeh (University of Rostock / Deutsches Biomasseforschungszentrum), Germany

ORAL PRESENTATIONS (PARALLEL-SESSIONS)

	SESSION 3 BIOCHEMICAL CONVERSION **Host: Prof. Dr. Michael Nelles, Dr. Hans Oechsner**	SESSION 4 THERMOCHEMICAL CONVERSION **Host: Prof. Dr. Jürgen Karl**
11:05	**Method development for the characterization of feedstock materials for box type dry digestion processes** Harald Wedwitschka (University of Rostock / DBFZ), Germany	**Clean combustion by combined adaption of wood pellet dimensions and design of a pellet stove with a capacity below 6kW** Roman Adam (Technical University Bergakademie Freiberg / DBFZ), Germany
11:30	**Using thrust to control the mixing process in biogas fermenters** Markus Kolano (Technical University of Berlin), Germany	**Agglomeration tendency of synthetic biogenic ashes in fluidised bed gasification** Benjamin Nun (Friedrich-Alexander-University Erlangen-Nürnberg), Germany
11:55	**Development of practical methods for parameter determination for model-based process monitoring on biogas plants** Johan Grope (University of Rostock), Germany	**Comparison of different methods to determine volatile matter and carbon content of biochars** Markus Lang (RWTH Aachen University), Germany
12:20	**Optimization of ensiling fermentation of Elodea genus for biogas production** Daniela Gallegos Ibanez (University of Rostock / DBFZ), Germany	**Procedure for the development of catalysts for the reduction of emissions from small-scale combustion plants** René Bindig (Martin-Luther-University Halle-Wittenberg / DBFZ), Germany
12:45 /12:50	**Break / Optional Networking-Session for questions & discussion to Session 3**	**Break / Optional Networking-Session for questions & discussion to Session 4**

POSTER-SPEEDPRESENTATION

13:30 - 14:45 SESSION 5
BIOREFINERIES
Host: Prof. Dr. Andrea Kruse

1	**Comparative performance of two different locally made corncob electrodes and graphite for electricity generation in microbial fuel cells (MFCs)** Musa Bishir (University of Hohenheim), Germany
2	**Influence of intraparticle processes on the simulation of fast pyrolysis of biomass in an auger reactor** Eugen Aschenbrenner (KIT - Karlsruhe Institute of Technology), Germany
3	**Purification and valorization of C_5-sugars from wood hydrolysates using hydrothermal processes and membrane filtration** Roy Nitzsche (Technical University of Berlin / Deutsches Biomasseforschungszentrum), Germany
4	**Improvements in the gas cleaning of a biomass based hydrogen production plant** Jürgen Loipersböck (Vienna Technical University / BEST - Biomass and Sustainable Technologies), Austria
5	**Evaluation of the vineyards with the biorefinery approach** Sevim Özgül (Ege University), Turkey
6	**The effect of pH, Ca/Si ratio and equilibration time on Al up-take in calcium silicate hydrates (C-S-H)** Sonya Barzgar (EPLF - École Polytechnique Fédérale de Lausanne), Switzerland
7	**Thermochemical pre-treatments for the hydrothermal liquefaction of sewage sludge** Joscha Zimmermann (KIT - Karlsruhe Institute of Technology), Germany
8	**Hydrothermal liquefaction of biogenic residues and microalgae** Thomas Braunsperger (Montanuniversität Leoben), Austria
9	**Hydrothermal liquefaction of waste biomass** Christian Klüpfel (Technical University of Berlin / Deutsches Biomasseforschungszentrum), Germany
10	**Hydrothermal carbonization of OFSMW for sustainable energy generation – Alternative treatment paths to current waste management practices in German** Niklas Stobernack, Technische Hochschule Köln
11	**Revealing the chemical composition of bio-oils derived from spirulina, miscanthus, and sewage sludge-based biomass by soft-ionization high-resolution mass spectrometry** Daniil Salionov (EPFL - École Polytechnique Fédérale de Lausanne / PLI - Paul Scherrer Institute), Switzerland
12	**Production of oxymethylene ether as renewable liquid fuel in an anhydrous process** Marius Drexler (KIT - Karlsruhe Institute of Technology), Germany

ORAL PRESENTATIONS (PARALLEL-SESSION)

	SESSION 5 BIOREFINERIES **Host: Prof. Dr. Nicolaus Dahmen**	SESSION 6 THERMOCHEMICAL CONVERSION **Host: Dr. Kathrin Weber**
14:45	**ProMo – A tool for the systematic modelling of biorefinery processes** Robert Pujan (NTNU - Norwegian University of Technology and Natural Sciences / DBFZ), Germany	**Data analysis and CFD simulations based on live data of a biomass cogeneration plant for emission prediction and reduction** Johannes Lukas (Friedrich-Alexander-University Erlangen-Nürnberg), Germany
15:10	**Path of process development for hydrothermal production of furfural from biomass and biomass hydrolysates** Jakob Köchermann (Technical University of Berlin / DBFZ), Germany	**In-situ activation of K-feldspar by fuel ash layers for DFB steam gasification** Katharina Fürsatz (Vienna University of Technology / BEST – Bioenergy and Sustainable Technologies GmbH), Austria
15:35	**A comprehensive model for liquid hydrocarbon fuel production via hydrothermal liquefaction – combining a complex reaction network with a simulation of a process chain** Leonard Moser (Bauhaus Aviation e.V.), Germany	**Development of a pellet boiler for micro-CHP with an organic rankine cycle** Maximilian Weitzer (Friedrich-Alexander-University Erlangen-Nürnberg), Germany
16:00	**Flexibility options for demand side management in biorefineries** Lilli Sophia Röder (DBFZ), Germany	**Numerical simulation of fuel nitrogen conversion and NOx emissions in biomass boilers with advanced air staging technology** Michael Eßl (Graz University of Technology / BEST – Bioenergy and Sustainable Technologies GmbH), Austria
16:25	**Optional Networking-Session for questions & discussion to Session 5**	**Optional Networking-Session for questions & discussion to Session 6**

CLOSING

16:25	**Closing of the 3rd Doctoral Colloquium BIOENERGY with subsequent Poster Award**
16:45	**Farewell**
16:45 - 17:30	**Evaluation of the event** (internal meeting)

POSTER PRESENTATIONS

SESSION 1
SUSTAINABLE RESOURCE BASE

3RD DOCTORAL COLLOQUIUM BIOENERGY

17th September, 2020 | 15:20 - 16:25

Semra Ocak, BOĞAZİÇİ UNIVERSITY

Biofuels from wastes in the Marmara Region, Turkey: Potentials and constraints

Semra Ocak
BOĞAZİÇİ UNIVERSITY
Bebek
34342, Beşiktaş/İstanbul
Phone.: +90 5320125127
E-Mail: **semraocak@hotmail.com**

Renewable energy sources have gained importance in the world to ensure energy security as well as energy independence and to mitigate environmental effects of conventional energy sources based on fossil fuels. Turkey as an energy importing country, is heavily dependent on fossil fuels, which causes an increase in environmental problems and raises concerns on energy security. Although the use of renewable energy sources is an increasing tendency, neither the share of renewable energy sources in electricity generation nor the share of bioenergy amongst these resources are at the expected level to avoid these challenges. In Turkey, hydropower holds a major share in renewable energy production, while biomass use holds a minor share. However, biowastes offer a significant potential in Turkey, especially in the Marmara Region of the country. In this study, the waste potential of the Marmara Region for energy production is analyzed. Within this context, agricultural and livestock wastes are examined in terms of their amounts, theoretical energy potentials and costs to generate electricity. Our analysis is carried out at provincial level in the region using data from national databases and aims at demonstrating which province provides higher waste amounts and, thus, energy potential, and which method is more economical to produce electricity. To evaluate economic costs, collection and feedstock costs for animal and agricultural wastes in the region are handled in three different scenarios based on FAO's assessment. In our analysis, all agricultural and animal feedstock are assumed to be available in order to be mobilized for electricity generation. Given the results for wastes and energy potentials in the region, it has been deduced that biowastes can theoretically meet more than half of the electricity consumption of the region. The results of the cost analysis demonstrate that both direct combustion of agricultural wastes and conversion of animal wastes to biogas in CHP plants to produce electricity are economical according to several scenario options considering the LCOE and feed-in-tariff values. This paper finds that the Marmara Region has a substantial potential in terms of agricultural and animal wastes, which might contribute to the accelerating rise of the renewable energy market in Turkey.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

BIOFUELS FROM WASTES IN THE MARMARA REGION, TURKEY: POTENTIALS AND CONSTRAINTS

Semra Ocak, Boğaziçi University, Institute of Environmental Sciences
Assoc. Prof. Dr. Sevil Acar, Boğaziçi University, School of Applied Disciplines

ABSTRACT

Turkey as an energy importing country, is heavily dependent on fossil fuels. However, biowastes offer a significant potential in Turkey, especially in the Marmara Region of the country. This study analyzes the waste potential of the Marmara Region for energy production by using data from national databases and aims at demonstrating which method is more economical to produce electricity. To evaluate economic costs, collection and feedstock costs for animal and agricultural wastes in the region are handled in three different scenarios based on FAO's assessment. In our analysis, all agricultural and animal feedstock are assumed to be available in order to be mobilized for electricity generation.

DATA AND METHODOLOGY

Cost assessments were made based on three scenarios adapted from FAO's "BEFS Assessment for Turkey" Report [1].

1. Determining the amount of crop residues and animal manure in the Marmara Region taken from the publicly available data on MENR General Directorate of Energy Affairs website [2] and calculating their theoretical energy equivalents in terms of megawatt-hours (MWh).
2. Calculating and comparing costs of energy production from biowastes and other sources by using some parts of the techno-economic analysis of the FAO's Report.

Energy production methods considered here consist of direct combustion from crop residues and biogas production from animal manure. It is addressed electricity generation in combined heat and power (CHP) or cogeneration systems from direct combustion or from biogas.

MARMARA REGION

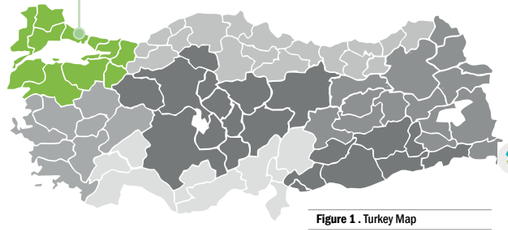


Figure 1 . Turkey Map

Table 1 . Animal and agricultural production/waste and their energy equivalents in the Marmara Region

	The Number of Livestock and Poultry	Animal Waste Amount (ton)	Energy Equivalence (toe/year)	Agricultural Production (ton)	The Amount of Agri. Waste (ton)	Energy Equivalence (toe/year)	Total Energy Equivalence* (toe/year)
TOTAL	99356687	22696294.16	890558.48	14930841	9375558.91	3763096.69	4653655.17

Source: Ministry of Energy and Natural Resources General Directorate of Energy Affairs, 2019. *Total energy equivalence is equal to the sum of energy equivalences of animal waste and agricultural waste.

- Total energy equivalence = 4653655.17 toe/year = 54122 GWh (1 toe = 11.63 MWh)
The total licensed electricity generation in 2018 = 295442.15 GWh [3]
Our assessment covering theoretical energy production corresponds to 18.32% of the total electricity generation of the country.
- Electricity consumption in the Marmara Region = 93324352 MWh (93324.35 GWh) [4]
57.99% of it could be theoretically covered by generating electricity from biowastes of the region.

COST CALCULATION FOR ELECTRICITY PRODUCTION

Collection and feedstock costs are used to determine proxies for the biomass price.
Given FAO's cost assessments, total costs are determined based on three scenarios as follows:

Table 2 . Estimated total costs per kWh for agricultural wastes in provinces

DIRECT COMBUSTION				
		TOTAL COST FOR COGENERATION (CHP)		
City	Amount of Agricultural Waste (ton)	Scenario 1* - 0 USD/t + Scenario 1** - 19 USD/t	Scenario 2 - 150 USD/t + Scenario 1 - 65.5 USD/t	Scenario 3 - 300 USD/t + Scenario 3 - 112 USD/t
Balıkesir	1096113.83	20826162.77	236212530.4	451598898
Bilecik	205588.1	3906173.9	44304235.55	84702297.2
Bursa	1512406.29	28735719.51	325923555.5	623111391.5
Çanakkale	865126.53	16437404.07	186434767.2	356432130.4
Edirne	1755665.87	33357651.53	378345994.99	723334338.4
İstanbul	345642.47	6567206.93	74485952.29	142404697.6
Kırklareli	1067270.3	20278135.7	229996749.7	439715363.6
Kocaeli	149094.91	2832803.29	32129953.11	61427102.92
Sakarya	643708.91	12230469.29	138719270.1	265208070.9
Tekirdağ	1706775.31	32428730.89	367810079.3	703191427.7
Yalova	28166.39	535161.41	6069857.05	11604552.68
TOTAL	9375558.91	178135619.3	2020432945	1050062598
1 ton 1.162 MW-hour >>	10894399.45 MWh	16.351 USD/MWh	185.456 USD/MWh	354.562 USD/MW
		0.016 USD/kWh	0.186 USD/kWh	0.355 USD/kWh

*Collection cost (transport excluded) **Feedstock costs

Table 3 . Total costs for biogas production from animal wastes

BIOGAS TO ELECTRICITY				
		TOTAL COST FOR COGENERATION (CHP)		
City	Animal Waste Amount (ton)	Scenario 1* - 14 USD/t + Scenario 1** - 3 USD/t	Scenario 2 - 35 USD/t + Scenario 2 – 6.5 USD/t	Scenario 3 - 55 USD/t + Scenario 3 - 10 USD/t
Balıkesir	6885871.04	117059808	285763648	447581618
Bilecik	614734.68	10450490	25511489	39957754
Bursa	3004653.29	51079106	124693112	195302464
Çanakkale	2569039.77	43673676	106615150	166987585
Edirne	1714313.9	29143336	71144027	111430404
İstanbul	1005106.56	17086812	41711922	65331926
Kırklareli	1710213.94	29073637	70973879	111163906
Kocaeli	1133270.57	19265600	47030729	73662587
Sakarya	2230372.77	37916337	92560470	144974230
Tekirdağ	1688142.18	28698417	70057900	109729242
Yalova	140575.46	2389783	5833882	9137405
TOTAL	22696294.16	385837001	941896208	1475259120
	26373093.63 MWh	14.630 USD/MWh	35.715 USD/MWh	55.938 USD/MWh
		0.015 USD/kWh	0.036 USD/kWh	0.055 USD/kWh

*Collection cost (transport excluded) **Feedstock costs

RESULTS

- Electricity production by obtaining biogas from animal wastes can be considered as the most economical option.
- As an indicator to evaluate cost-efficiency of energy generation methods "levelized cost of electricity (LCOE)" is also used.
- LCOE value in Turkey can be considered as 0.08 USD/kWh by using the LCOE value in Europe. Thus, scenario 1 for crop residues and all scenarios for animal wastes in our analysis appear to be economical. When feedstock costs are equal to zero, the same result prevails.

DISCUSSION AND CONCLUSION

- Biowastes can theoretically provide more than half of the electricity consumption of the region.
- Costs of energy generation of wastes indicate an economical option considering several scenario selections.
- Energy-related agricultural production is another problem which leads to increase in food prices, loss of biodiversity, soil degradation, water pollution etc. Thus, getting benefit from wastes is emphasized in this study instead of producing crops for energy in arable lands.

REFERENCES

[1] Maltsoglou, I., Rincon, L., Kojakovic, A., & Puri, M. (2016). BEFS assessment for Turkey. Environment and Natural Resources Management. FAO Working Paper eng no. 64.
[2] Ministry of Energy and Natural Resources General Directorate of Energy Affairs (MENR) (2019) https://bepa.enerji.gov.tr/ Date accessed March 2020.
[3] Energy Market Regulatory Authority (EMRA) (2019), Electricity Market - 2018 Market Development Report, Ankara, 2019. https://www.epdk.org.tr/Detay/Icerik/3-0-24/elektrikyillik-sektor-raporu Date accessed May 2020.
[4] Turkish Statistical Institute (TurkStat), http://www.tuik.gov.tr/UstMenu.do?metod=temelist Date accessed March 2020.

3RD DOCTORAL COLLOQUIUM BIOENERGY

17th September, 2020 | 15:20 - 16:25

André Brosowski, Deutsches Biomasseforschungszentrum

National Resource Monitoring for Biogenic Residues, By-products and Wastes – Development of a Systematic Data Collection, Management and Assessment for Germany

Brosowski, André; Krause, Tim; Mantau, Udo; Mahro, Bernd; Noke, Anja; Richter, Felix; Raussen, Thomas; Bischof, Roland, Hering, Thomas; Blanke, Christian; Müller, Paul; Bill, Ralf; Prof. Dr. Thrän, Daniela
Leipzig University
Grimmaische Str. 12
04109 Leipzig
Phone: +49 (0)341 2434-718
E-Mail: **andre.brosowski@dbfz.de**

The efficient use of biogenic residues, by-products and waste offers numerous advantages. Besides fulfilling public service requirements, a smart cascading can provide alternative sources of carbon and can also play an important role in a system for the use of renewable sources of energy. However, a comprehensive overview of the existing resources and their current use is required as a sufficient basis for decision-making. The doctoral thesis therefore deals with the development, testing and implementation of a monitoring system that is consistent across sectors and can be updated regularly. The system includes a total of twelve modules that are connected to each other and ensure automated data processing, transparent documentation and flexible data provision.

The balancing of the biomass supply and use is understood here as a process that includes a systematic assessment of data quality and its continuous improvement. For the case study Germany, a total of 77 biogenic residues, by-products and waste from the five sectors agriculture, forestry, municipal waste and sewage sludge, industrial residues and residues from other areas were differentiated. With the help of 1.113 calculation elements, a theoretical biomass potential of 199-278 million t DM was determined for the most recent common reference year 2015. About half of this is available as technical potential. Between 66-84% are already established in use and the still mobilisable technical potential is in the range of 14-48 million t DM. If these potentials were used energetically, up to 15% of the primary energy demand could be covered by biogenic residues in future. The focus here is on less than ten biomasses. With regard to data quality and the consideration of relevant sustainability criteria within the biomass potential calculation, data gaps exist above all in the fields of soil erosion, soil compaction, nutrient losses, biodiversity and eutrophication of ecosystems. The monitoring system can be used to identify priorities for further steps with regard to mobilisation or optimisation strategies for future utilisation of resources and the stepwise improvement of the data basis. Political and entrepreneurial decisions can thus be supported crucially.

Publications:
1 (published) https://doi.org/10.1016/j.biombioe.2016.10.017
2 (published) https://doi.org/10.1016/j.biombioe.2019.105275 3. (in review) 10.21203/rs.3.rs-16344/v1

17th September, 2020 | 15:20 - 16:25

Tom Karras, Deutsches Biomasseforschungszentrum

A review on supply cost of biogenic resources in Europe

Tom Karras, André Brosowski
Leipzig University
Grimmaische Str. 12
04109 Leipzig
Phone: +49 (0)341 243-610
E-Mail: **tom.karras@dbfz.de**

Biogenic residues and by-products have the potential to make an important and increasing contribution to achieving climate targets without competing with food or feed production. In this context, the supply cost have a considerable influence on the extent of the future use of residual biomass. An initial screening of the existing costs for biomass supply at European level shows that the existing costs or prices are not available in a satisfactory quality. For this reason, the PhD aims to determine the supply cost of different biogenic residues and to map them over time. In the first step of the PhD thesis, a literature review for the European context is used to analyze the status quo regarding cost and price information in a structured way. For this purpose, the countries of the EU-28 serve as a spatial scope.

Studies from 2010 to 2020 are investigated. After the most relevant biogenic residues have been identified based on their technical potential for Europe, a structured literature search is conducted using the Scopus database. Combinations of keywords for the relevant biomasses, the spatial scope and the supply cost are queried as a search string in the database. The relevant studies are determined from the search results by an abstract screening. Six criteria have been chosen in order to analyze the cost information of these studies with regard to data quality. These criteria are monetary value, unit, spatial scope, time reference, type of cost and source. Subsequently, the cited sources for the cost information are analyzed according to the same six criteria. With this approach the study and the cited source, thus the associated data quality can be compared.

The described method and preliminary results will be presented at the doctoral colloquium. From the first results, tendencies towards the status quo of the data quality of costs can be deduced. The strengths and weaknesses of the status quo will later form the starting point for further steps of the PhD thesis, which will include the development of a supply cost model.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

A review on supply costs of biogenic resources in Europe

Tom Karras[1], André Brosowski [1], Daniela Thrän[1,2]

Context & Objective

The transformation to a bio-economy is a necessary step towards reducing greenhouse gases and the associated mitigation of climate change. In this context, the supply costs of the bio based resources play an important role for the economy of the material or energetic utilization processes. The status quo of the existing cost information of biomass supply in literature will be evaluated in a review.

Methode

Scope

Spatial resolution	Year of publication	Biomass types/ Residues
EU-28 National	2010 - 2020	Most relevant residual biomass, by-products and waste

Literature selection

Most relevant residues (technical potential)	Cost & price information
Keywords combination on Scopus	Keywords combination on Scopus
"Europe" "EU-28" + "Residues" (or synonym) + "Potential" (or synonym)	"Europe" "EU-28" + "Residues" (most relevant) + "Feedstock cost" (or synonym)
Article = 138	Article = 569
Access = 83	Access = 351
Relevant = 13	Relevant = 48

Review criteria

The review criteria are applied on the selected literature/ studies and their linked references

- Spatial resolution
- Monetary dimension
- Biomass type
- Temporal resolution
- Monetary value
- Unit

Preliminary Results

The preliminary results show that the number of studies that offer supply costs or prices for multiple biomass types from the three sectors of agriculture, forestry and waste management are limited. The use of different units and scope of supply makes it difficult to compare the monetary values. The cost information usually refers to only one reference year and does not reflect cost developments over a period of several years.
It also shows that the quoted sources are partially outdated.

Outlook

For this reason, a supply cost model is to be developed in the next steps of the PhD project which will map the supply costs of biogenic residues in Germany on county level (NUTS-3) and over a period of multiple years.

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Contact: Tom Karras | E-Mail: tom.karras@dbfz.de | Phone: +49 (0)341 2434-610

[1] Deutsches Biomasseforschungszentrum (DBFZ), Bioenergy Systems Department, Torgauer Straße 116, 04347 Leipzig, Germany
[2] Helmholtz Centre for Environmental Research (UFZ), Bioenergy Department, Permoserstr. 15, 04318 Leipzig, Germany

DBFZ

17th September, 2020 | 15:20 - 16:25

Olivier Hirschler, Thünen Institut

Peat use reduction and biomass market in Germany

Olivier Hirschler
Leipzig University
Grimmaische Str. 12
04109 Leipzig
E-Mail: **olivier.hirschler@thuenen.de**

Peat is an organic material extracted from drained peatland soils and used in horticultural growing media for professional and hobby purposes.
Because of its high carbon content, peat extraction and use release CO_2 in the atmosphere through aerobic metabolism. In the context of growing climate concerns, emissions from peat trigger tense debates. In Germany, the goal to reduce its use was set in the Climate Action Plan in 2016 and in the coalition agreement between the governing parties in 2018, and a strategy is currently being developed by the Federal Ministry of Food and Agriculture. Today, a large share of the horticultural systems in Germany and Europe is based on growing media in which peat is by far the main component. Therefore, peat use reduction implies developing the use of alternatives. Currently, the main other components are green compost, wood fibres, cocopith, bark and minerals. Their implementation on a larger scale is a technical challenge for the horticultural industry, but also implies to supply the growing media sector with materials in sufficient quantity, quality at an acceptable price.
In this project, the goal is to understand the possibilities and the consequences of a reduction of peat use in Germany on the biomass market and the mitigation of GHG emissions. The first step is to evaluate the quantities of peat to be replaced, the place of Germany on the European mar-ket, the GHG mitiga tion potential and the current involvement of governments on this issue. To achieve this goal, the existing data is used to quantify peat flows within and between the European countries, and the different policies regarding peat are analysed. First results show that within Europe, Germany constitutes a central actor and peat is intensively traded. Policies to reduce peat in horticulture exist in the UK, Switzerland and Germany, but the issue is not addressed on a European level yet. The second goal is to evaluate the current and potential use of alternative biomass components, as well as the challenges linked to an increased demand for horticulture. To achieve this, qualitative and quantitative descriptions of the different sources and uses of alternative materials will be developed using flow models and analysing biomass potentials. Despite sufficient amounts of alternative components physically and technically available, an important competition occurs from the increased demand for sustainable and local biomass, especially wood products and compost. This limits the economical availability and can trigger displacement effects, which can complicate the assessment of the climate potential of peat replacement. The goal of the third step is therefore to identify the required conditions and the consequences of an increased use of biomass in the growing media industry.
The method used needs to be further developed and will involve quantifying the costs linked to biomass use and building prospective scenarios.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG
THÜNEN

PEAT USE REDUCTION AND BIOMASS MARKET IN GERMANY

Olivier Hirschler, Bernhard Osterburg
Coordination Unit Climate, Thünen-Institut, Braunschweig, Germany

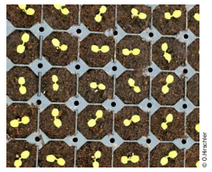


Figure 1: Peat-based growing media

BACKGROUND

Peat is an essential constituent for horticultural growing media, a local fuel source in specific countries and a significant source of greenhouse gases. In its Climate Action Plan 2050, the German government commited to reduce peat extraction and use.

What are the possibilities and the consequences on the biomass market of replacing peat through alternative products?

EUROPEAN PEAT MARKET AND CLIMATE IMPACTS

As a first step, we evaluate the current situation of peat in Europe to estimate the quantities of peat that need to be replaced and identify potential trade-offs linked to peat reduction.

- Material Flow Analysis of peat in Europe:
  - Based on official statistics combined with literature : overall lack of coherence and data,
  - Importance of trade, central role of Germany.
- Evaluation of the emissions from peat:
  - Methodology IPCC (on-site + off-site)
  - Importance of the approach
- Political goals:
  - In the EU, emissions from horticulture peat will be accountable for climate policy by 2026
  - Political goals to reduce peat use in the UK, Switzerland and Germany

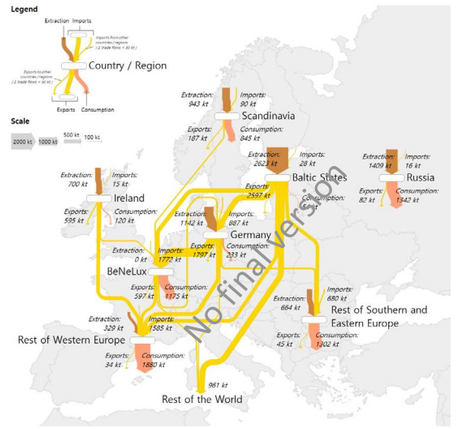


Figure 2: Material flows of non-energy peat in Europe (average 2013-2017)

ALTERNATIVE PRODUCTS: POTENTIAL AND CHALLENGES

Most alternatives are based on waste biomass products. In order to evaluate their future potential use, the following aspects are investigated:


Figure 3: Wood product for horticultural use

- Available amounts (potentials)
- Competition with other sectors
- Determining factors of the price

Amount of alternatives needed to substitute peat:
7 - 8 Mio. m³ per year (current peat use in Germany)

Alternative product	Use for horticulture[1]	Theoritical potential[2]	Challenges
Wood fibers	500	400.000	Dependance on the sawmill industry, competition with the energy sector
Composted bark	300	22.000	
Green compost	750	4.300	Transport and processing costs for a sufficient quality
Cocopith and -fibers	100	6.000 (World exports)	Dependance on imports, processing costs
Sphagnum	1	0?	Development of paludiculture and labour costs

Figure 4: Actual amounts, potential and challenges of alternative products as growing media in Germany. Unit: 1.000 m³. Source: [1]IVG and [2]own calculations, maximal theoretically available amount of a product in a given region (here Germany).

CONCLUSION AND FURTHER QUESTIONS

- Because of the major trade flows, peat reduction needs to be addressed at European level.
- Alternative products are available in large quantities in Germany
- What policy measures can allow an increased supply of alternative products?

THÜNEN
Contact: Olivier Hirschler, Coordination Unit Climate, Thünen-Institut, Braunschweig, Germany
E-Mail: olivier.hirschler@thuenen.de

17th September, 2020 | 15:20 - 16:25

Seung Hye Lee, TBI / INSA Toulouse

Making Sense of Global Future Storylines in the Perspective of Sustainable Bioeconomy Planning

Seung Hye Lee, Lorie Hamelin, Ligia Barna
INSA Toulouse
135, Avenue de Rangueil
31077 Toulouse Cedex 4
E-Mail: **seunghye@insa-toulouse.fr**

The transition from fossil-dependent to low-fossil bioeconomy requires a variety of investments in infrastructures. Since the lifespan of the projects and infrastructures are long term, taking future conditions into account is important in making investment decisions for bioeconomy. The PhD project will develop prospective LCA methodologies that contribute to dynamic, time-dependent inventories for bioeconomy strategies for France. The inventories will reflect the carbon dynamics and circularity in biomass conversion chains, enabling to quantify the environmental impacts of national bioeconomy strategies over time. Since predicting one single future is impossible, the study will have multiple plausible background futures, on which the time-dependent inventories will be built. This will enable us to explore the strategies under different possibilities, enhancing the robustness. For that, we aim to find internationally well-recognized sets of scenarios and adapt them to have bioeconomy and national-level focus.

In this study, five future scenarios studies by intergovernmental initiatives featuring 18 scenarios have been reviewed, namely five Shared Socioeconomic Pathways to be used in the assessments of the Intergovernmental Panel for Climate Change, three scenarios from the International Energy Agency, three scenarios from the Food and Agriculture Organization, four scenarios from the World Economic Forum, and three scenarios the European Commission. The result shows that most studies focus primarily on energy, food and climate change aspects while the aspects of bioeconomy and the “materials” (e.g. chemicals, pharmaceuticals, construction materials) were largely missing. Deeper look into the parameters common assumptions and the causal relationships between the parameters in each study showed that while different logics and causal relationships are observed across the studies, many common assumptions (e.g. population, economic growth) are still shared unquestioned. Further discussions can be made with most of the climate scenarios missing the various disruptors such as pandemic.

FAO. The future of food and agriculture – Alternative pathways to 2050. FAO, 2018.
International Energy Agency. World energy outlook. IEA/OECD, 2019.
M‘barek, R., G. Philippidis, and T. Ronzon. „Alternative Global Transition Pathways to 2050: Prospects
for the Bioeconomy.“ (2019).
O’Neill, Brian C., et al. „The roads ahead: Narratives for shared socioeconomic pathways describing
world futures in the 21st century.“ Global Environmental Change 42 (2017): 169-180.
Riahi, Keywan, et al. „The shared socioeconomic pathways and their energy, land use, and greenhouse
gas emissions implications: an overview.“ Global Environmental Change 42 (2017): 153-168.
Schwab, K. „Shaping the future of global food systems: A scenarios analysis.“ World Economic Forum
Report. 2017.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Making Sense of Global Future Storylines in the Perspective of Bioeconomy Planning

Seung Hye **Lee***, Lorie **Hamelin***, Ligia **Barna***
*Toulouse Biotechnology Institute (TBI), INSA, INRAE UMR792, and CNRS UMR5504, Federal University of Toulouse, 135 Avenue de Rangueil, F-31077, Toulouse, France
seunghye@insa-toulouse.fr

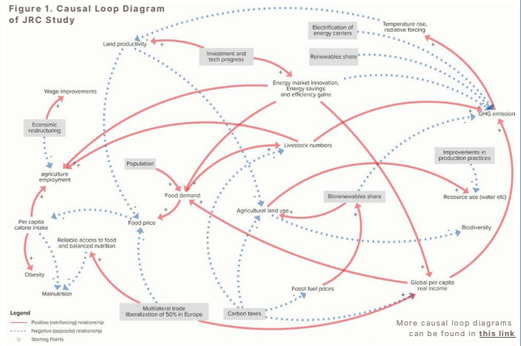
GRAPHICAL SUMMARY

STUDIES	SSP	IEA	FAO	WEF	OECD	JRC	DNI
SCENARIOS	5	3	3	4	1	3	4
VARIABLES	CATEGORIES		VARIABLES				
	• Demographics • Human development • Economy • Lifestyle & demand • Policies and institutions • Technology • Environment and resources		• Population, migration.. • Human health, education level, social justice.. • Economic growth, GDP, income, trade liberalization.. • Healthy and sustainable diet.. • Mitigation policies, international cooperation, institutions strength.. • Technological development.. • GHG emissions, climate change, natural ecosystems, materials use..				

▼ IDENTIFY CAUSAL RELATIONSHIPS ASSUMED IN THE STUDIES ▼

ONE DIAGRAM PER STUDY (EXAMPLE BELOW)

Figure 1. Causal Loop Diagram of JRC Study



More causal loop diagrams can be found in **this link**

▼ COMBINE THE DIAGRAMS INTO ONE TABLE ▼

SORT BY FREQUENCY OF APPEARANCE OF CAUSAL RELATIONSHIPS

	Climate Change	Material Use	Food Security	Eco-systems	Shocks	Food price	Econ Growth	Social Justice	Land Use	Human Health
Climate Policies	IEA JRC SSP	JRC	JRC	JRC SSP	WEF	SSP	JRC	FAO	JRC SSP	WEF FAO
Tech. Progress	FAO SSP	SSP	FAO				SSP		JRC	
Consumer Awareness		WEF	WEF FAO			WEF		WEF FAO		WEF FAO
Education Level	DNI		SSP		DNI		OECD IEA	WEF FAO		SSP
Market Liberalization	SSP		JRC WEF	SSP		WEF SSP JRC	WEF SSP JRC	SSP		WEF
Global Cooperation	SSP WEF	SSP	FAO		WEF		SSP	FAO SSP		
Economic Growth	JRC	OECD JRC DNI		JRC		JRC			JRC	
Institutions Strength	WEF				WEF		OECD	FAO		
Healthy & Sustainable Diet	SSP	WEF	WEF	SSP	WEF	WEF SSP			SSP	WEF SSP
Population		OECD	JRC	JRC		JRC	JRC		JRC	

Table 1: Top 10 causal variables (in rows) and Top 10 resulting variables (in columns).
The acronyms in the cells represent the studies where the causal relationship between two variables were mentioned, and the color of the cells represent the causal relationship directions.
Positive (red), column value increase -> row value increases, **Negative (blue)** column value increase -> row value decreases, **Multidirection (yellow)**

Introduction: Background futures for prospective LCA for bioeconomy
- For bioeconomy planning, taking future conditions into account is critical due to long lifespan of projects and infrastructures.
- The PhD project aims to develop prospective LCA methodologies that contribute to dynamic, time-dependent inventories.
- Building the inventories on multiple plausible futures will enhance robustness of the planning, instead of having one projected future.
- The study reviews various well-recognized global climate and environmental future scenario studies to identify key drivers

Methodologies: Reviewed Studies
- SSPs: Shared Socioeconomic Pathways from Integrated Assessment Modeling (IAM) Community
- IEA: International Energy Agency's World Energy Outlook
- FAO: Food and Agriculture Organization's Future of Food and Agriculture
- WEF: World Economic Forum's Shaping the Future of Global Food System
- OECD: Organisation for Economic Co-operation and Development's Global Material Resources Outlook to 2060.
- JRC: Joint Research Centre of European Commission's Alternative Global Transition Pathways to 2050
- DNI: US National Intelligence Council's Global Trends 2030: Alternative Worlds

Methodologies: Identifying Causal Relationships and Key Drivers
- Causal loop diagrams visualize causal relationships between variables and are one of the most recognized methods to represent complex systems.
- It can also identify the key drivers that play critical roles in the systems.
- This study identifies the causal relationships that are perceived and/or assumed by the reviewed studies

Results (More causal loop diagrams can be found in **this link**)
- Causal loop diagrams were constructed for all 7 studies (one example shown as **Figure 1** on the left).
- Top 10 causal variables, the ones with most connections as causal factors, and the top 10 resulting variables, the ones with most connections as resulting factors were summarized in the **Table 1**.
  - Causal variables: Mitigation policies, technological progress, consumer awareness, education level, market liberalization, global cooperation, economic growth, institutions strength, healthy & sustainable diet, population.
  - Resulting variables: Climate change, materials use, food security, natural ecosystems, shocks and crises, food price, economic growth, social justice, land use, human health.
- Top variables identified are often critical across most reviewed studies but some variables only appear in certain studies and the level of connection also differs across studies.

Discussions
- Lack of systems thinking
  - Feedback loops from the climate & environmental outcomes are not considered enough.
    - There is only one variable, economic growth, that shows up both as a main causal variable and as a main resulting variable.
    - Most variables related climate and environmental outcomes are only end results of causal relationships but hardly starting points of the causal relationships.
    - Some studies show more feedback loops (e.g. JRC study), better representing the complexity of the system while some explicitly not include the climate outcome back into the socioeconomic factors (e.g. SSPs).
    - Evidences show that the climate change and natural ecosystems destruction have impact back to the human society, disrupting the food system, resource system and political systems, however, this consideration is lacking in most reviewed studies.
  - Some studies have critical variables such as population and economic growth fixed exogenously instead of having influences from other socioeconomic and environmental variables of the system.
- Shocks and disruptions are not considered enough.
  - Reviewed climate and environmental studies tend not to consider extremes and hardly consider sudden, unexpected and disruptive events such as pandemic, natural disasters, wars, changes of global power dynamics, and disruptive technologies and future of work.
  - These disruptive events may have lower probability of occurrence, yet can have great impacts in global and multi-sectoral scale, as the 2020 Covid-19 pandemic has shown.
  - However, intelligence reports, such as the DNI study, has been considering these disruptive events with importance, including severe pandemic, rapid climate change, solar geomagnetic storms, nuclear war, collapse of EU and China.
- The effect of trade and trade liberalization is largely simplified.
  - Trade liberalization almost always leads to increase in sustainability, as in reduction of GHG emissions, and enhancement of natural ecosystems in most reviewed studies.
    - However there are many arguments that trade liberalization act as a key barrier of sustainability.
  - Trade liberalization also always leads to economic growth in reviewed studies.
  - Local movement is mostly considered as the result of trade barriers, nationalistic movements and lack of global cooperation.
    - However, local movement for food and energy can still be done under cooperative world, since food and energy sovereignty are key issues of most countries. Local movement may even be necessary for resilience of the system and increasing sustainability through shorter supply chains.
- Limited representation of economic outcome.
  - In most reviewed studies, economic growth is a key driver and is almost always represented with GDP.
  - It is also the only variable that is included both in top 10 causal variables and top 10 resulting variables.
  - In reviewed studies GDP mostly increases. When GDP decreases, it is always associated with "recession" or "collapse", and there is no single scenario that reaches a "sustainable world" with stable or decreasing GDP.
  - However, whether GDP can be an indicator that can represent desired quality of life and whether sustainable world can only be possible under growing GDP is questionable.
  - Income is almost always shown as GDP per capita. However, is GDP divided by population a good enough factor to represent income, while not taking the distribution factor into account?
- Insufficient representation of supply and demand of bioeconomy sources and services.
  - Biomass are mostly considered as food and energy sources yet it can and should replace materials in other sectors such as platform chemicals, pharmaceuticals, plastics, textiles etc.
  - Also, biomass supply also varies greatly across regions and is highly affected by disruptive events and trade, which are two factors that are not considered sufficiently in reviewed studies.

Perspectives
- Key disruptors are not dealt much in existing climate and environmental scenario studies but are critical for biomass supply and demand.

17th September, 2020 | 15:20 - 16:25

Zhou Shen, INSA Toulouse

Simultaneous carbon storage in arable land and anthropogenic products (CSAAP): demonstrating a new concept towards well below 2 °C

Zhou Shen, Ligia Barna, Lorie Hamelin, Aras Ahmadi, Shivesh Karan
Institut National des Sciences Apliquées (INSA) - Toulouse
135, Avenue de Rangueil
31400 Toulouse
Phone.: +59 (0)393 9942495
E-Mail: **zshen@insa-toulouse.fr**

To meet the target of controlling global warming to less than 1.5 °C by the end of this century, the function of soil sequestering carbon from the atmosphere by plants through photosynthesis has been observed, as the soil is estimated to have a high carbon storage capacity. Therefore, biopump is proposed as one of the climate change mitigation strategies. Biopumps are plants that could increase soil organic carbon (SOC) during growth and could be used as raw materials for long life sustainable products in the technosphere. A shortlist of biopumps is proposed and ranked in this work. Biomaterials and plant-based chemicals are candidates for long lifetime products, maintaining carbon flows in the technosphere and avoiding CO_2 emissions for decades. To illustrate the concept, an example of miscanthus with anthropogenic products of different lifetimes are studied through 3 scenarios. The carbon flow balance and the global mean temperature change are calculated to study the efficiency of carbon sequestration. The best scenario allowed to sequester 790.81 kg C/ ha in 2100. In France, there are up to 24007.4 km^2 of land suitable for biopump cultivation. In the most optimistic case, biopumps could offset 8.08% of France's annual carbon budget.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Simultaneous carbon storage in arable land and anthropogenic products (CSAAP): demonstrating a new concept towards well below 2°C

Zhou Shen[1], Ligia Barna[1], Aras Ahmadi[1], Shivesh Karan[1], Lorie Hamlin[1]

Biopump – for sequestering CO_2

To meet the target of controlling global warming within 1.5°C at the end of this century, the function of the soil sequestering the carbon from the atmosphere by plants through photosynthesis has been noticed, as the soil is estimated to have high capacity to store carbon. Therefore, biopump is proposed to be one of the strategies to mitigate climate change. Biopumps are plants that could increase the soil organic carbon (SOC) during the growth, and could be used as raw material for long lasting products in the technosphere.

To select which kind of plant may be involved, biopump candidates are scored according to criteria including yield, SOC increase capacity, etc. Plants in the top rank have high potential to be used (criteria are made in French condition)

Carbon vulnerable land

Obviously, areas that already occupied by cites, highways and crops are not suitable to grow biopump. According to the French land-use data, there are 23 classes of land-use. Furthermore, areas with SOC at least lower than 50t/ ha are considered may have potential to sequester more carbon. Based on these two pinciples, the land that may suit for biopump, called as carbon vulnerable land, is explored in France, estimated to be 11,187 km^2 to 14,007 km^2(fig. 1).

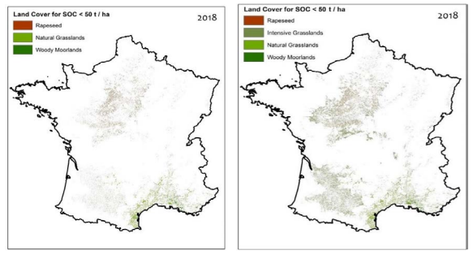


Fig. 1 – Carbon vulnerable lands identified as potentially suitable for biopumps implementation in France, without (left) and with (right) Intensive Grasslands.

Feasibility of biopump strategy

The influence of the biobased product lifetime (L) and biogenic carbon fraction stored (F) were investigated through a sensitivity analysis with the following cases:

-F100L100: the net biogenic C harvested (i.e. 45% C from 10t of plants/ha) is stored in a product with very long lifetime (e.g. a composite building wall) and with multiple recycling loops, i.e. a global storage time higher than 100years. No biogenic C is lost as gas.

-F100L1: the whole harvested C is used as a product with short lifetime (1 year), and incineration as end of life (e.g. the product is a biofuel).

-FxLy/Fx'Ly': the biogenic C harvested is shared between two co-products with the fractions Fx and Fx', with different lifetimes Ly and Ly' (e.g. a fibre based material and a biofuel), and all biogenic C is emitted as CO2 at the end of life of the products (e.g. incineration).

An example of potential biopump (*Miscanthus*) is shown in fig. 2.

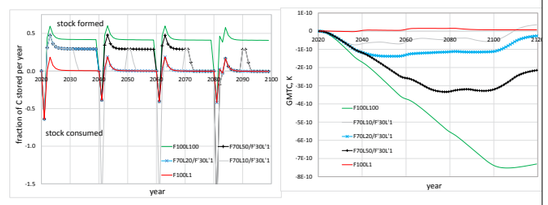


Figure 2. Sensitivity analysis on biogenic carbon balance in case of miscanthus. a) left – fraction of biogenic carbon stored per year; b) right – global mean temperature change.

The potential of biopump strategy

If the biopump strategy is fully applied in all identified carbon vulnerable lands in France, 5,3Mt CO_2 is calculated to be converted from the atmosphere into soil annually. In the most optimistic assumption, making harvested biopumps into products which have a long lifetime (like the wall), the integral biopump chain would 40,95 Mt CO_2, which could offset 8.08% of French annual carbon budget.

1 Toulouse Biotechnology Institute (TBI), INSA, INRAE UMR792 and CNRS UMR5504, Federal University of Toulouse, 135 Avenue de Rangueil, F-31077, Toulouse, France

3RD DOCTORAL COLLOQUIUM BIOENERGY

17th September, 2020 | 15:20 - 16:25

Muhammad Angga Kusuma, University Rostock

Investigation of Heavy Metal Content in solid material at the Cement Plant that applies Coprocessing

Muhammad Angga Kusuma, Abdallah Nassour, Prof. Dr. Michael Nelles
University Rostock
Justus-von-Liebig-Weg 6
18059 Rostock
Phone: +49 (0)6285 67184480
E-Mail: **m.angga.kusuma@gmail.com**

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Investigation of Heavy Metal Content in solid material at the Cement Plant that applies Co-processing Of Waste

Muhammad Angga Kusuma[1], Abdallah Nassour[2], and Michael Nelles[3]

Investigation

Heavy metal content investigations have been carried out at the cement plant which located in Bogor Regency, Indonesia that has 1.3 million/year of clinker production capacity by trough precalciner technology. The cement plant has natural resource substitution of 17% for alternative fuel and 3% for raw-material in 2019. The Heavy metal testing is conducted by using the Epsilon 5 EDXRF Spectrometer which refers to US EPA Method 6010 C dan ASTM C114. The sampling of each materials is carried out twice a week or 8 times a month on the same day. On the day of sampling, the sampling is done on 3 shifts which will be composted into 1 sample. The investigation has been conducted for 8 months from October 2019 - May 2020. So there are 64 samples in this period for each material in clinkerization and cement process as shown in the figure 1 and its composition in Kiln system as shown in the figure 2.

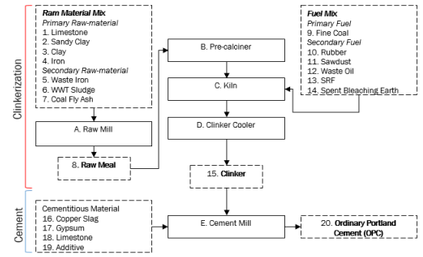


Figure 1: material flow investigation

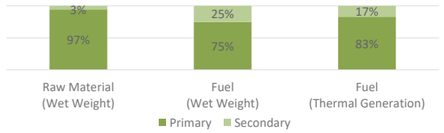


Figure 2: material component composition

Results

Figure 3 illustrates that Zn has the highest content followed by Cu and Ni. As content in input materials, clinker and OPC are <lod or <1 ppm. The trend of heavy metal content in the clinkerization and cement process tends to increase. According to Achternbosch, (2003), 1.55 tons of rawmeal are required to produce 1 tonne of clinker. So that heavy metal will gather in the solid phase/clinker from the calcination or combustion. However, the ratio of increasing heavy metal content between Clinker and rawmeal is not necessarily the same, this is due to various factors, such as the buildup of materials and gas circulation from the previous process. While the heavy metal content of cement products is influenced by its constituent components.

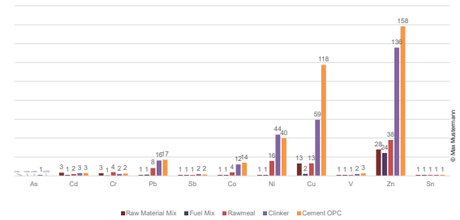


Figure 3: Comparison of heavy metals concentration in ppm

Conclusion

The heavy metal content in Clinker and Cement tends to be higher than the material input, this is due to the accumulation of heavy metal in the solid phase. For example for the dominant type of heavy metal, Zn, Cu, and Ni. The Zn content in rawmeal was 38 ppm, then increased at clinker = 136 ppm and even higher at Cement OPC = 158 ppm. Then for Cu, the content in raw meal is 13 ppm and then increases at clinker = 59 ppm then higher at Cement OPC = 118ppm. Whereas for NI, the content in raw meal is 16 ppm and then increased to 44 ppm in clinker, then slightly decreased at Cement OPC = 40 ppm.

[1] University of Rostock
Department Waste Management and Material Flow, Rostock, Germany

Universität Rostock Traditio et Innovatio

POSTER PRESENTATIONS

SESSION 2
SYSTEM ANALYSIS BIOENERGY

3RD DOCTORAL COLLOQUIUM BIOENERGY

17th September, 2020 | 15:20 - 16:25

Katrin Beer, OVGU Magdeburg

How Bioenergy Policy in Germany can be explained. A policy analysis of RED II, EEG and EEWärmeG.

Karin Beer
OVGU Magdeburg
Zschokkestrasse 32
39104 Magdeburg
Phone: +49 (0)176 63121346
E-Mail: **katrin.beer@ovgu.de**

Climate neutrality by the year 2050 has been stated as a political goal both by the European Union and by the German government (BMUB 2016). For a future renewable energy system, bioenergy plays an important role, as there are limitations to the use of other renewables regarding for instance the possibility to store fuels and to use them flexibly (Beer et al. 2018).

It is the task of political institutions to create a framework that helps to achieve defined political goals. From a perspective that understands political processes as processes of problem solving (Böcher/Töller 2012), one could hence expect that decisions are made and measures are taken that lead to climate neutrality by increasing the share of renewables, including bioenergy, as much as possible and as fast as possible in order to replace fossil fuels. After setting an example for the successful transformation of the energy system and becoming a forerunner with the German Energiewende (Lehmann et al. 2017; Hook 2018), the German government however changed its course and slowed down the energy transition in the second decade of the 21st century. The political support of bioenergy has been reduced remarkably, leaving potential for the reduction of CO_2 emissions unused (Beer et al. 2018; Daniel Gromke 2017).

How can this political situation be explained? What are the factors that influence political processes and the resulting political measures of bioenergy policy in Germany? Based on three empirical case studies, the proposed contribution aims at giving answers to these questions from a political science perspective. Applying the political process inherent dynamics approach (PIDA), political processes on the European and German level connected to RED II, EEG and EEWärmeG have been analyzed in order to identify unique characteristics as well as overarching patterns in these political processes (Beer et al. 2018; Böcher/Töller 2012). The overall aim of this study was to reveal causal mechanisms in political processes that help to explain political decisions in bioenergy policy. The results can serve as a starting point for further studies and as a basis for policy consultation and other kinds of political work.

Beer, K. et al. (2018): Politische Prozesse der Bioökonomie zwischen Ökonomie und Ökologie. Bio-Ökopoli-Arbeitsbericht 1.
BMUB (2016): Klimaschutzplan 2050. Böcher, Michael; Töller, Annette Elisabeth (2012): Umweltpolitik in Deutschland.
Daniel-Gromke, J. (2017): Anlagenbestand Biogas und Biomethan - Biogaserzeugung und -nutzung in Deutschland. DBFZ Report: Nr. 30.
Hook, Sandra (2018): ‚Energiewende': Von internationalen Klimaabkommen bis hin zum deutschen Erneuerbaren-Energien-Gesetz. In: Olaf Kühne und Florian Weber (Hg.): Bausteine der Energiewende. Wiesbaden, Germany: Springer VS, S. 21–54.
Lehmann, Paul et al (2017): 20 Jahre EEG: Ist das Förderende für alte Anlagen ein Problem für die Energiewende? In: Wirtschaftsdienst Volume 97 (Issue 10), S. 727–732.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

How bioenergy policy in Germany can be explained. A policy analysis of RED II, EEG and EEWärmeG

M.Sc. Katrin Beer*, Prof. Dr. Michael Böcher*

Background

Climate neutrality by the year 2050 has been stated as a political goal both by the European Union and by the German government. Bioenergy plays an essential role in this context.

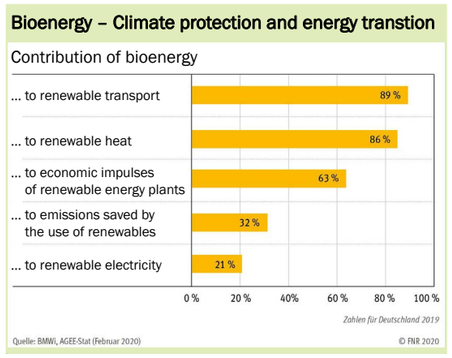


Figure 1: Contribution of bioenrgy to climate protection and energy transition (Source: FNR)

However, political decisions in bioenergy policy in the past have not led to the most effective measures for reducing CO_2 emissions. How can this be explained?

Aim and approach

This PhD research project aims to show how political processes of bioenergy policy in Germany are shaped and which factors determine the results of these processes. The analysis is based on case studies for three selected policies:

- RED II: Regulating renewables on EU level
- EEG: Regulating renewables in the power sector on national level
- EEWärmeG: Regulating renewables in the heat/cold sector on national level

Political process-inherent dynamics approach (PIDA)

PIDA is the analytical framework for policy analysis that has been applied in this study. It helps to identify factors which influence political processes and their results (policies).

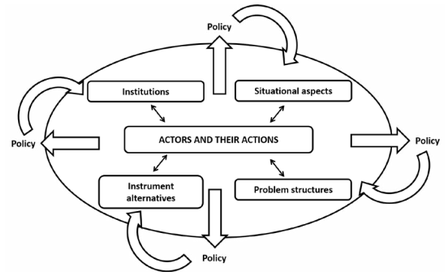


Figure 2: PIDA and its five explanatory factors

Results: Characteristics of bioenergy policy in Germany

The analysis of 30 expert interviews, primary documents and scientific literature with PIDA led to the following findings:

Bioenergy policy in Germany is maily shaped by
- conflicting goals (climate/biodiversity protection, food/energy/supply security, economic growth),
- unclear definitions of problems and solutions,
- a highly diverse actor structure with relatively weakly organized actors,
- a diverse institutional framework which is hard to oversee and where political regulations are scattered across several policy fields, sectors and political levels,
- emotional/value-based debates rather than fact-based discussions on national level in the 2010s

To tap the full potential of bioenergy for climate protection and the energy transition, the inherent dynamics of bioenergy policy processes need to be considered.

Otto von Guericke University Magdeburg | Faculty of Humanities, Social Science & Education | Zschokkestr. 32 | 39104 Magdeburg | www.ovgu.de
Contact: Katrin Beer | E-Mail: katrin.beer@ovgu.de

*Department of Political Science, Chair for Political Science with a Focus on Sustainable Development

17th September, 2020 | 15:20 - 16:25

Alena Hahn, Deutsches Biomasseforschungszentrum

Carbon capture readiness of German bioenergy plants: Retrofit criteria as tool for assessing near-term potential for CO_2 utilization and storage

Alena Hahn, Dr. Nora Szarka, Prof. Dr. Daniela Thrän
DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Str. 116
04347 Leipzig
E-Mail: **alena.hahn@dbfz.de**

For achieving a below 1.5 °C pathway as targeted by the Paris Agreement, negative emission technologies (NETs), such as bioenergy with carbon capture and storage (BECCS), are likely to play an important role in compensating residual emissions and temporary emission overshoots. In view of ramping up BECCS capacities to significant amounts of negative emissions by mid-century, some scenario studies require to start implementing BECCS as early as the 2020s. So far, only few studies consider near-term BECCS potentials. Despite being a major barrier to timely BECCS deployment and upscaling, research on retrofitting brownfield bioenergy plants is scarce, both in terms of techno-economic feasibility and from a systems perspective.

For short-term BECCS deployment, existing CO_2 transport and storage infrastructure will be of particular importance. However, as the location of bioenergy plants does not necessarily coincides with geological CO_2 storage sites, other options for bioenergy with carbon capture and utilization (BECCU) should be assessed in parallel. While BECCU does not fall under the NETs umbrella, it is nevertheless a means of replacing fossil carbon inputs by renewable biogenic ones. However, research on integrated BECC(U)S perspective is still in its infancy, especially in terms of emissions accounting for BECCU. Given these research gaps, the present study develops retrofit criteria for a representative set of bioenergy plant types, taking into account CO_2 capture specificities, both on plant and systems level, as well as the CO_2 valorization through BECC(U)S. To this end, a systematic literature search is carried out to collect relevant parameters for retrofitting. This is further supplemented by a mapping of existing BECC(U)S pilot and demonstration projects to add practical experience on retrofitting options and their implementation.

The preliminary criteria for BECC(U)S retrofitability are techno-economic factors (technology readiness level, costs for both reconfigurations and additional energy requirements of the capture unit), emission data (CO_2 capture rate, volume and quality) and systems parameter (carbon prices, storage site locations, CO_2 demand). This set of criteria allows to identify suitable brownfield bioenergy plants for the integration of CO_2 capture units with subsequent CO_2 storage or utilization.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Carbon capture readiness of German bioenergy plants: Retrofit criteria as tool for assessing near-term potential for CO_2 utilization and storage

Alena Hahn[1,2], Nora Szarka[1], Daniela Thrän[1,2]

CONTEXT & RESEARCH GAP

In a 1.5˚C world, negative emission technologies (NETs), such as bioenergy with carbon capture and storage (BECCS), are likely to play an important role in compensating residual emissions. To ramp up BECCS capacities, deployment as early as in the 2020s would be required. However, only few studies consider near-term BECCS potentials and **dedicated research on retrofitting brownfield bioenergy plants with CO_2 capture is lacking altogether**. In addition, as the location of bioenergy plants does often not coincides with geological CO_2 storage sites, other options for bioenergy with carbon capture and utilization (BECCU) should be assessed in parallel.

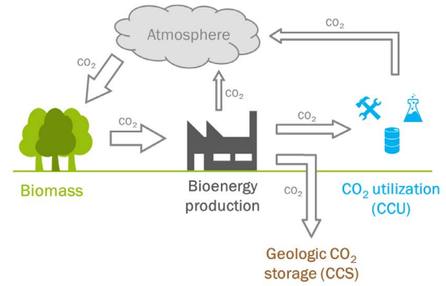


Fig. 1: Schematic view of BECCS and BECCU. The CO_2 captured during bioenergy production can be geologically stored (BECCS) or used as a raw material (BECCU).

AIM & METHODS

The present study develops retrofit criteria for a representative set of bioenergy plant types, taking into account CO_2 capture specificities, both on plant and systems level, as well as the CO_2 valorization through BECC(U)S. To this end, (1) relevant parameters for retrofitting are collected via a systematic literature search. This is further supplemented by (2) a mapping of existing BECC(U)S pilot projects to add practical experience on retrofitting options and their implementation.

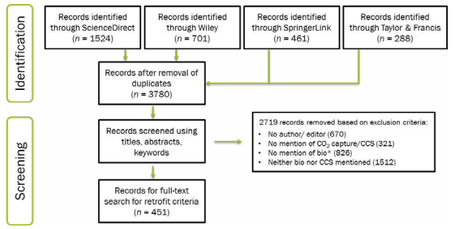


Fig. 2. Structured literature review to identify and screen relevant papers.

Project Name/ Company	Country	Status	CO2 capacity (MtCO2/yr)	CO2 source	Technology
Arkalon Bioethanol	USA	Operating since 2009/2010	0,39 (0,105 in Italy)	Conestoga's Arkalon ethanol plant	
ARV Duiven	Netherlands	under construction in 2017; planned start 2018	aim: 0,05	Waste incineration plant (54% biomass)	MEA solvent
Bonanza Bioenergy	USA	Operating since 2011	0,15	Conestoga's Bonanza BioEnergy ethanol plant	High purity source
CPER Arteney Project	France	2008-2010	0,045 captured from fermentation; 0,0605 from natural gas fired cogeneration	Two sugar beet ethanol refineries (Arteney and Toury): CO2 from fermentation process and from natural gas fired cogeneration unit	High purity source (fermentation); amine-based post-combustion capture process for natural gas fired cogeneration
Energy and Environmental Research Center (EERC) Pilot BECCS plant	USA	Pilot		Biomass gasification	High purity source
ENOS (ENabling ONshore CO2 storage in Europe) greenVISION	Europe Germany	Sept 2016 - Aug 2020 in operation			
Husky Energy	Canada	Operating since 2012	0,1	Ethanol plant	
Illinois Basin Decatur Project (IBDP)	USA	Operating since 2011; until 2014/15 ?	0,3 (1,0 in total)	Archer Daniels Midland ethanol plant	High purity source
Illinois Industrial CCS (IL-ICCS)	USA	Operating since April 2017	1,1 (5,5 in total over 5 years)	ADM corn processing facility	

Fig. 3. Excerpt of BECC(S) pilot and demonstration plant mapping. Information provided on plant location, CO_2 source, CO_2 capture technology and capacity.

PRELIMINARY RESULTS & OUTLOOK

The preliminary criteria for BECC(U)S retrofitability are **techno-economic factors** (technology readiness level, costs for both reconfigurations and additional energy requirements of the capture unit), **emission data** (CO_2 capture rate, volume and quality) and **systems parameter** (carbon prices, storage site locations, CO_2 demand). This set of criteria allows to identify suitable brownfield bioenergy plants for the integration of CO_2 capture units with subsequent CO_2 storage or utilization. In a next step, these criteria will be applied to the German case to determine its near-term potential for BECC(U)S.

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartnerin: Alena Hahn | E-Mail: alena.hahn@dbfz.de | Telefon: +49 (0)341 2434-600

[1] DBFZ, Bioenergy Systems Department, Leipzig
[2] Helmholtz Center for Environmental Research UFZ, Bioenergy Department, Leipzig

17th September, 2020 | 15:20 - 16:25

Felix Mayer, TH Köln

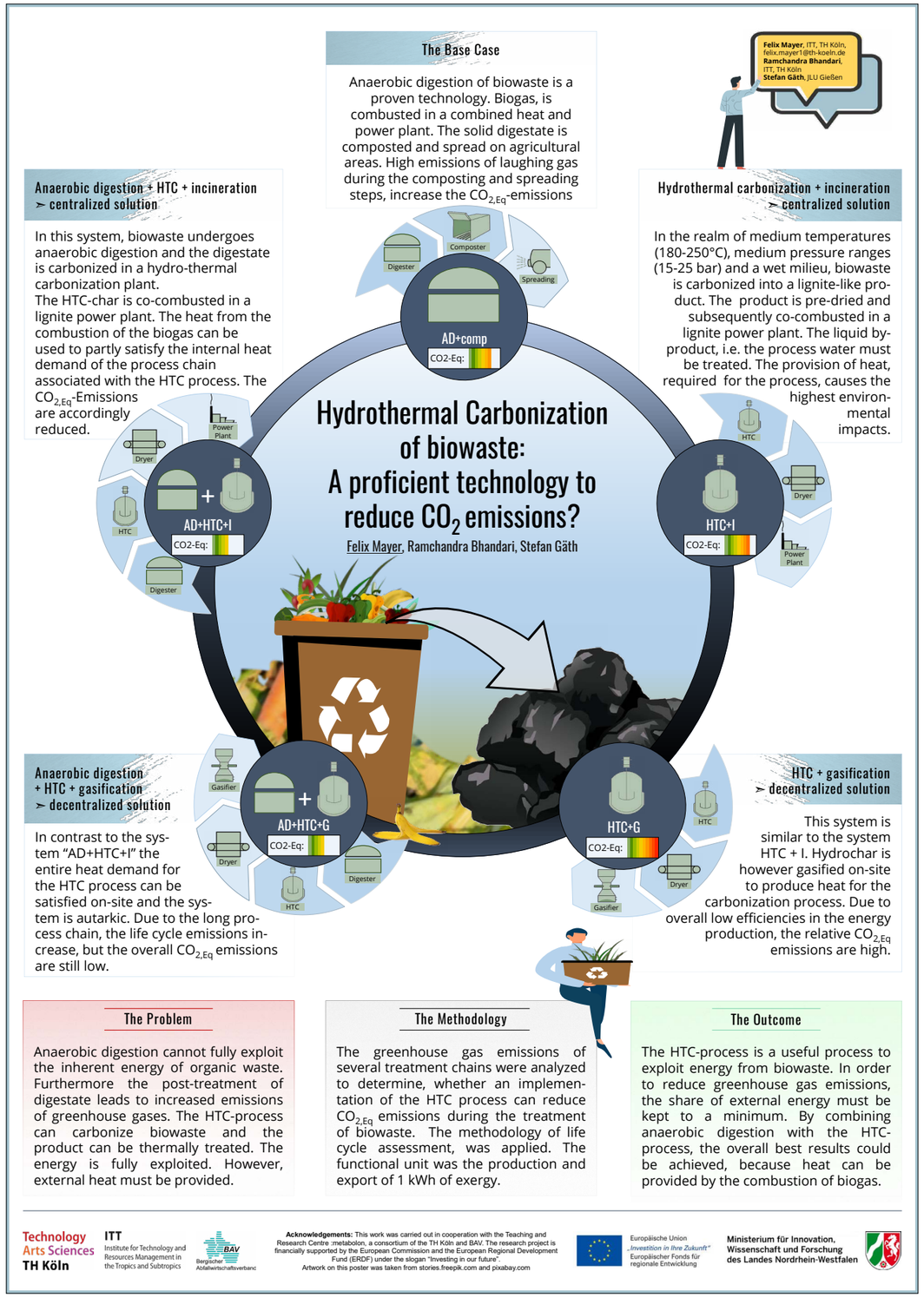
Hydrothermal Carbonization of biowaste – A proficient technology to reduce CO_2- emissions?

Felix Mayer, Ramchandra Bhandari, Stefan A. Gäth
TH Köln
Ludwigstraße 23
35390 Gießen
E-Mail: **felix.mayer1@th-koeln.de**

As of 2012 source-segregation of the organic fraction of municipal solid waste (OFMSW) became mandatory in Germany. Based on this premise, OFMSW was decoupled from mass-burning and tangible benefits, such as enhanced recovery rates from this waste stream were facilitated. To allow for a maximum exploitation of the respective potential of OFMSW, an optimal treatment path is key. Anaerobic digestion, followed by composting of the solid digestate, has developed as the best practice solution in this realm. However, increased methane and laughing gas emissions during the process chain result in an increased global warming potential (GWP), and thus counteracts an environmentally sound solution. Further, competitive treatment options must therefore be investigated. While multiple biological and thermo-chemical treatment paths are available, to treat OFMSW, this study focuses on a novel treatment option, the hydrothermal carbonization (HTC). In the past years, thorough research has been conducted on this technology, but its environmental performance was hardly ever determined or compared to anaerobic digestion.

This study holistically balances the GWP of four treatment paths for OFMSW, which partly or fully substitute anaerobic digestion followed by composting:
1) HTC+I: OFMSW is converted in an HTC process and the solid product, i.e. HTC-char is co-combusted in a lignite power plant
2) HTC+G: similar to 1, but HTC-char is gasified in a decentralized plant
3) AD+HTC+I: OFMSW undergoes anaerobic digestion and the digestated is sent to a HTC-plant. HTC-char is co-combusted in lignite power plant
4) AD+HTC+G: similar to 3, but the HTC-char is gasified

In the realm of an environmental life cycle assessment (eLCA), energy and resource consumptions, as well as ancillary and capital goods are balanced for each process within the prospected process chain. The activity starts at the gate of the treatment plant and end with the production of energy and the disposal of any byproducts. All process chains are referenced towards the production of 1 kWh of exergy.
The assessment showed that treatment paths containing an HTC-step hold the potential to outcompete anaerobic digestion followed by composting with regards to the GWP. The outcome is highly susceptible to the source of heat, which is used to fuel the HTC-process. The systems AD+HTC+I and AD+HTC+G are nearly autarkic with regards to heat: high temperature heat, which is produced from the combustion of biogas in combined heat and power plants can be utilized to fuel the HTC-infrastructure. As a consequence, they are viewed as the most promising options.



17th September, 2020 | 15:20 - 16:25

Steffi Dietrich, Leibniz-Zentrum für Agrarlandschaftsforschung (ZALF) Müncheberg e.V.

Evaluation of political instruments regarding their potential to reduce regional nitrogen surpluses

Steffi Dietrich, Dr. Sandra Uthes, Dr. Jana Zscheischler
Martin Luther University Halle-Wittenberg
Universitätsplatz 10
06099 Halle
E-Mail: **steffi.dietrich@zalf.de**

Nitrogen surpluses in the soil caused by agriculture, especially in livestock-intensive regions, have long been a topic that national and international policy-makers have been trying to improve through various measures such as the Renewable Energy Act (EEG) and the Fertilizing Ordinance (DüV). However, despite a variety of measures and even after 20 years of the Nitrate Directive, the nutrient balances are not within the limits prescribed by the EU, and in some cases are more than twice as high.

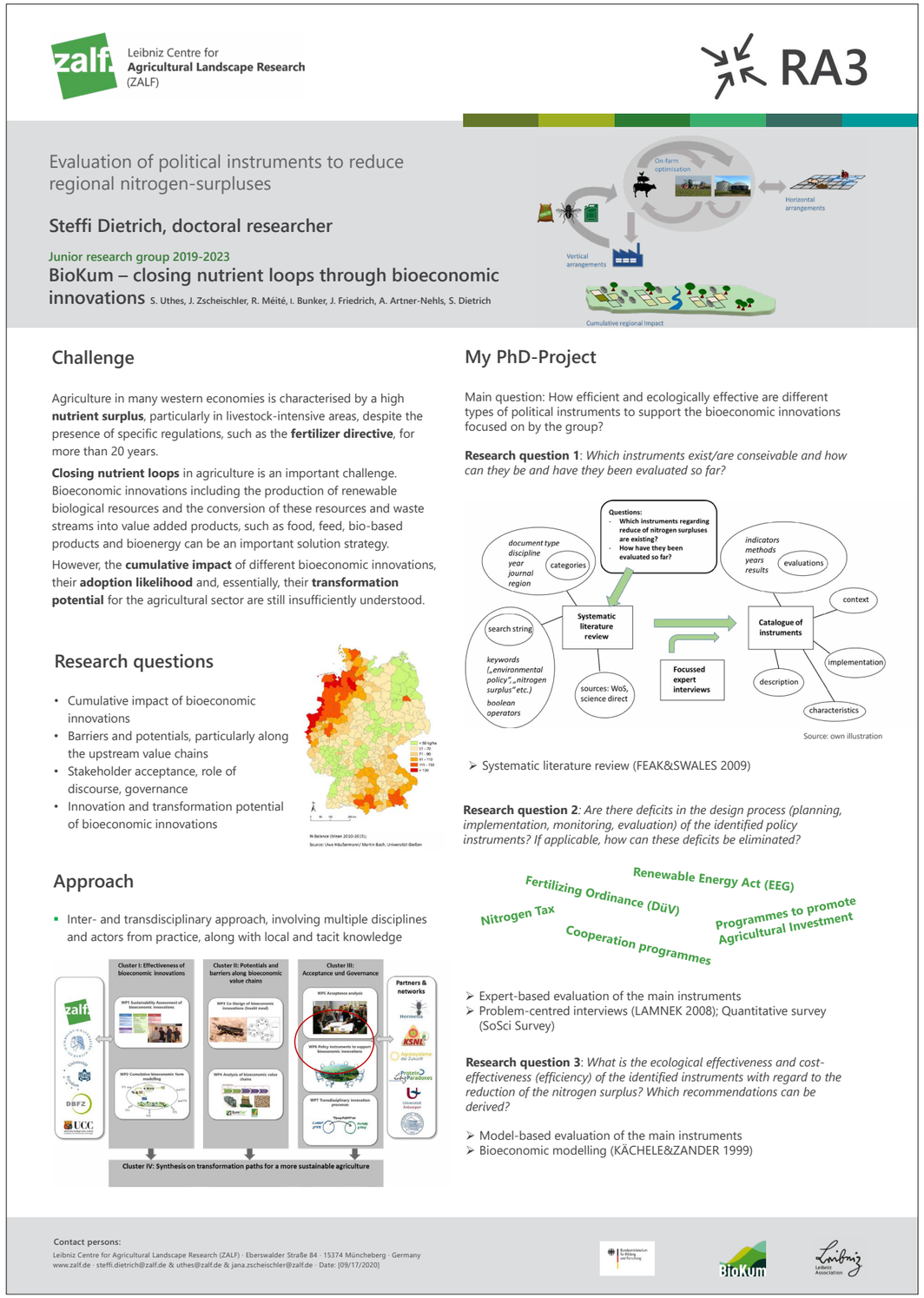
In the BMBF-funded project BioKum - Cumulative Effects of Bioeconomic Strategies for a More Sustainable Agriculture - innovations for the reduction of nitrogen surpluses are examined for their cumulative effects. An interdisciplinary research approach is chosen, which is based on intra-, inter- and extra-farm level of agricultural practice in order to investigate and map the complex processes of transformative agriculture.

The content of my doctoral thesis is the policy instruments mentioned at the beginning, which should help to promote the innovations investigated in the framework of BioKum and thus the development towards a more sustainable agriculture. To this end, the first step will be a systematic literature analysis in order to compile a catalog of already existing instruments and their evaluation and categorization. There are different possibilities for this depending on the discipline and perspective. It will be investigated which instruments led to which effects and to what extent they were effective for the respective environmental goal. Undesirable side effects such as the maize problem (EEG) may arise. The effectiveness and efficiency of the instruments depends on various factors. Among other things, factors such as the participation of all actors and communication of the instruments can have a decisive influence on the success of an instrument in the policy-making process. Deficits here as well as an evaluation of the effectiveness will be ascertained through corresponding expert interviews and quantitative surveys. In the bio-economic model MODAM (Kächele and Zander 1999) different scenarios with and without policy instruments will be modelled and a ranking will be established, from which recommendations for further support measures of the European agricultural policy regarding the reduction of nitrogen surpluses can be derived. My research questions are in detail:

1. Which policy instruments with effects on the nitrogen surplus exist or are conceivable and how can they be systematized and evaluated?

2. Are there deficits in the design process (planning, implementation, monitoring, evaluation) of the identified policy instruments? If applicable, how can these deficits be eliminated?

3. What is the ecological effectiveness and cost-effectiveness (efficiency) of the identified instruments with regard to the reduction of the nitrogen surplus? Which recommendations can be derived?



17th September, 2020 | 15:20 - 16:25

Piradee Jusakulvijit, Helmholtz Centre for Environmental Research - UFZ

Potential assessment of second-generation bioethanol development from agricultural residues in Thailand with participatory selection of sustainability criteria

Piradee Jusakulvijit, Alberto Bezama, Prof. Dr. Daniela Thrän
University of Leipzig
Augustusplatz 10, 04109 Leipzig
E-Mail: **piradee.jusakulvijit@ufz.de**

Thailand established a long term goal to foster the proportions of bioethanol consumption in order to reduce the dependency of imported fossil fuel. Nonetheless, this national policy involves with a likelihood of land use expansion from the cultivation of conventional feedstocks. On the other hand, agricultural residues generated in farming process on a normal basis are mostly disposed by open field burning. Therefore, this study aims to propose a sustainable strategy for second-generation bioethanol development by utilizing undervalued agricultural residues in Thailand as input materials. As a preliminary examination, the study successfully confirmed that the existing lignocellulosic biomass in Thailand is sufficient and promising resource to substitute the conventional feeding materials for future bioethanol production. From the data of crops cultivation in 2018, generated residues from sugarcane, cassava, rice, and palm agricultures were totally found to be 174.1 million tons, which theoretically can be converted to bioethanol production for 59.8 million liters day- 1, covering 33.6% of the overall fuel demand of Thailand transport section. In addition to the quantitative analysis, the study from the geographical aspect showed that the northeastern and central regions are concentrated with high potential biomass. On account of the verified status quo, the study views the opportunity that Thailand could potentially utilize the leftover biomass to produce higher valued products. With an expectation to promote the second-generation ethanol in the policy for the sustainable bioenergy development, in addition to the potential from technical assessment, it is imperative to evaluate from interdisciplinary aspects in line with socioeconomic and environmental dimensions. The study investigated the preferable criteria by incorporating opinions from stakeholders through Delphi-survey, and quantified by multicriteria decision making analysis method, i.e. Analytical Hierarchical Process (AHP). The results of criteria prioritization reflected the most concerned criteria regarding importance of the factors based on the experts' point of views. The study found that, among technical, economic, social and environmental dimensions, stakeholders showed the highest concern on 'economic feasibility', whereas the second and third identified criteria in terms of importance were 'environmental impacts' and 'technical feasibility', respectively. 'Social impacts' was found to be the least engaging criteria. Furthermore, quantitative weighting of subcriteria under respective aspects resulted in the top three most prioritized factors which were raised by the participants to be 'final price of ethanol', 'added value of input material' and 'net energy balance'. The results of criteria prioritization are expected to contribute in the scenarios analysis in the future study, which can close the gap of socio-economic assessment.

Conclusion/Outlook

Based on the results, price developments of wood-based products can be assessed in dependence of raw material prices. These results are of interest for different stakeholders: For industries, assessing future price developments is important for operative and strategic decision making. Policy makers can use this information to develop efficient policy instruments fostering a sustainable development of a bioeconomy.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Potential assessment of second-generation bioethanol development from agricultural residues in Thailand with participatory selection of sustainability criteria

Piradee Jusakulvijit[1,2], Alberto Bezama[1], Daniela Thrän[1,2,3]

Background

Thailand's national policy to promote the bioethanol production involves concerns of land use expansion, and inappropriate disposal process of agricultural residues, e.g., open field burning. The current study proposed a sustainable strategy for second-generation bioethanol development by utilizing undervalued agricultural residues as input materials for bioethanol production which is expected to initiate the bio-based economy in Thailand.

Objective

- To assess the regional agricultural residues from major crops and verify the potential bioethanol production
- To incorporate stakeholder opinions from interdisciplinary aspects of technical, socio-economic and environmental dimensions, into the system analysis
- To encourage the utilization of regionalized biomass into the policy recommendation

Research process & Methodology

Preliminary study of biomass availability and distribution, and theoretical ethanol yields → Survey conduction with bioethanol stakeholders by Delphi – AHP method to prioritize criteria → Scenarios analysis from modelling and simulation → Multicriteria decision analysis and policy recommendation

Results I) Biomass availability & distribution

The major crops, sugarcane, cassava, rice and palm, were estimated for 174.1 MT y^{-1} of agricultural residues.

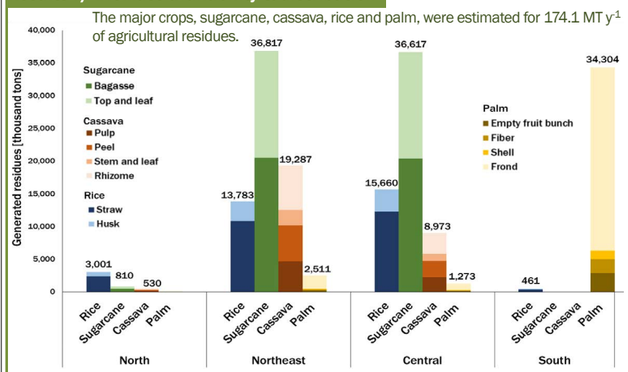
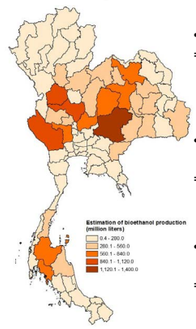


Fig. 1 Distribution of the regional agricultural residues from rice, sugarcane, cassava and palm as organized in this study

Regional potential of bioethanol estimation converting from distributed agricultural residues



- Total estimated volume = 20,214 ML y^{-1}, covering 31.2% of the overall fuel demand of the transport section.
- The highest regional estimation = Northeast 9,100 ML y^{-1}, following by central, northern and southern regions.
- The highest provincial estimation = Nakhon Ratchasima for 1,328 ML y^{-1}.

Fig. 2 Ethanol potential in provincial scale

Results II) Participatory criteria selection

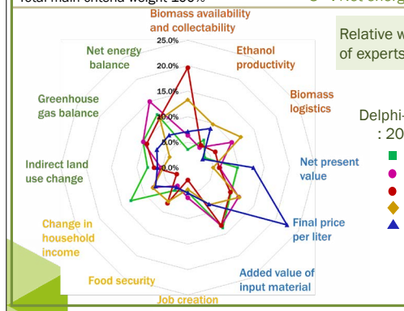
Main criteria

Economic feasibility 32.3%
Environmental impacts 25.6%
Technical feasibility 24.0%
Social impacts 18.1%
Total main criteria weight 100%

Sub criteria

Top 3 from 12 criteria
(total sub criteria weight 100%)
1st : Final price per liter of ethanol (12.8%)
2nd : Added value of input materials (11.7%)
3rd : Net energy balance (9.3%)

Relative weights of criteria by groups of experts



Delphi-AHP survey participants
: 20 experts from 5 organizations

- Government
- Industry / business sectors
- NPOs / NGOs
- Academic / research institutes
- Financial institution/ Bank

Discussion & Conclusions

- Available residues from sugarcane, cassava, rice and palm can be expected for a promising volume of bioethanol.
- The northeastern and central regions are the hotspot areas from sugarcane and cassava derived residues
- The southern region could be the first potential area for decentralized production by deploying palm's residues.
- The results suggested the possibility of mixing feedstocks

- Economic aspect is the most paid attention from stakeholder perspectives, following by environmental impacts, technical feasibility and social impacts.
- "Price per liter", "Added value of input material" from financial feasibility, and "Biomass availability and collectability" from technical aspects are the top three most important factors.
- Diverse functions and backgrounds of organizations represented different preferences of factors, which could contribute in the scenarios analysis as the further steps of ethanol policy planning.

Next steps

- Scenarios analysis based on selected indicators with an aim to promote a regionalization of agro-biomass for bioethanol

[1] Helmholtz Centre for Environmental Research – UFZ. Department of Bioenergy.
[2] University of Leipzig, Germany. Faculty of Economics and Management Science
[3] Deutsches Biomasseforschungszentrum gGmbH – DBFZ.

Helmholtz Centre for Environmental Research – UFZ. Department of Bioenergy|Torgauer Straße 116 | 04347 Leipzig | E-Mail: piradee.jusakulvijit@ufz.de| Telefon: +49 (0)341 2434-775

ORAL PRESENTATIONS

SESSION 1
SUSTAINABLE RESOURCE BASE

3RD DOCTORAL COLLOQUIUM BIOENERGY

17th September, 2020 | 16:30

Marilene Fuhrmann, BEST – Bioenergy and Sustainable Technologies GmbH

Sawmill by-products in a bioeconomy – Econometric analysis of price cointegration and value chain interlinkages

Marilene Fuhrmann, Dr. Christa Dißauer, DI Dr. Christoph Strasser,
Univ. Prof. DI Dr. Erwin Schmid
BOKU - University of Natural Resources and Life Sciences Vienna
Gregor-Mendel-Straße 33, 1180 Wien
Phone: +43 (5)02378-9453
E-Mail: **marilene.fuhrmann@best-research.eu**

Introduction

EU policies promote the use of biomass for material and energy purposes to foster a transition towards a sustainable bioeconomy. The European timber industries and wood markets will take a crucial role in this transition. Hence, two developments are already observable in the wood markets: (i) an increasing demand along well established wood value chains, and (ii) new actors on the demand side due to new technologies. Considering the competition for wood resources and the political initiatives for sustainable wood use, an increasing use of byproducts of the timber industry can be expected. Wood chips and sawdust are considered as most valuable, high quality by-products. Currently, the main users of these sawmill by-products (SBP) are the paper, panel and pellets industry. Rising demand and competition have already led to price increases. However, little is known about consequences on and price cointegration in SBP markets.

Research objective, data and methods

Price developments are very suitable for investigating market developments, since it is a determinant of supply and demand. The main research questions to be analysed are:

(1) How are product prices (paper, chipboard, pellets) related to raw material prices (pulpwood, wood chips, sawdust)?

(2) How are value chain interlinkages reflected in prices?

Econometric modelling will be employed to provide empirical results by using monthly price data of raw materials and products for the period Jan 2005 to Dec 2019. The analysis is based on a multi-stage approach: (1) An Augmented Dickey-Fuller test will be carried out to test for stationarity of the data, which is a prerequisite for further analysis. (2) The presence of linear cointegration between the prices of raw materials and products is tested using the bivariate Johansen Test. (3) Based on a threshold autoregressive cointegration test an asymmetric error-correction model is estimated in order to describe the short-term relationship between the commodity prices. Cointegration describes a co-movement of prices and can be used to describe price fluctuations across markets. Its analysis allows decision makers to respond appropriate to changing market conditions.

Interim results

First results show a significant decline in the prices of paper and chipboard as a consequence of the economic crisis in 2008. Such a decline is not visible for SBP prices, which can be explained by price cointegration with pellets - SBP were in continuous demand from the pellets industry.

17th September, 2020 | 16:55

Keyu Bao, HFT Stuttgart/University Leipzig

Modelling and Assessment of Biomass Resource in Urban Energy Systems within the Framework of the Food-Energy-Water Nexus

Keyu Bao
University Leipzig
Grimmaische Str. 12
04109 Leipzig
Phone: +49 (0)15221750180
E-Mail: **keyu.bao@hft-stuttgart.de**

Biomass is can be used in various forms: it can be food, building material, energy carrier or key input to industries. Especially in and around municipalities, biomass can not only be derived from agricultural land or forests[6], but can also be derived from urban waste. While some potential analysis, e.g. for urban green spaces, have already been performed [5], a consistent assessment of biomass potentials from different urban and rural sources, and its interdependencies to resources such as water has not been performed yet. The research question of this work will be: What are the local biomass resource potentials, their dependency on other resources, mainly water, their conflicts with other usage, e.g. food, and their contribution to renewable energy supply at the regional level?

In order to address this gap, Hochschule für Technik Stuttgart (HFT) and the Helmholtz-Zentrum für Umweltforschung (UFZ) aim to combine their expertise in the field of bioenergy and urban energy systems. In the project, HFT's urban energy modeling platform SimStadt will be extended to provide detailed information on biomass energy potentials in the whole region as well as water demands and food potentials. At the same time the urban waste analysis and biomass life cycle flow from UFZ will be also included in this research. Results from newly set-up workflows will be validated through case studies. Both tools will be coupled to allow having a holistic view on urban biomass systems, its potentials and its limitations.

Work has been done to introduce a new workflow in SimStadt which evaluates the local biomass potential from various sources, its transformation to different forms of secondary energy, e.g. solid fuels, biogas, or bioethanol, and their thermal and electrical energy potentials, based on GIS-based land use data, satellite map on local crop types, and crop-specific energy yields from literature.

13 scenarios for each case study were conducted to quantify the influence of forest usage rate, land area dedicated to energy crop and etc. One of the two case studies in Ludwigsburg shows in the typical scenario the annual secondary local biomass potential can meet 8% of total energy demand.

The results of the project will enable municipal and regional governments to better assess potential new resources, but also resource constraints, in existing cities and new developments, as well as enable them in developing more resource-integrated and sustainable city quarters.

The dissertation is to be submitted as a cumulative dissertation, which means that during the processing period, three scientific papers are to be written for peer-reviewed journals.

GIS-Based Assessment of Reginal Biomass Potentials for Heat and Power Generation

GIS-Based Assessment of Biomass on the Water Demand in Urban and Hinterland

Scenarios Analysis of Biomass and Bioeconomy in Regional Energy System: Synergies, Conflicts, Economic Merit orders and Potentials

17th September, 2020 | 17:20

Christhel Alejandra Andrade Díaz , Federal University of Toulouse

Considering the interaction between crop residues, bioeconomy conversion pathways and the return of carbon to soils

Christhel Andrade Díaz, Ezequiel ZamoraLedesma, Lorie Hamelin
Institut National des Sciences Apliquées (INSA) - Toulouse
135, Avenue de Rangueil, 31400 Toulouse
Phone: +59 3939942495
E-Mail: **andraded@insa-toulouse.fr**

Introduction
The current major feedstock to bioenergy is biomass [1, 2], however, its removal sustainability is an issue because excessive removal may reduce the soil organic carbon (SOC) stocks, degrading the long-term soil productivity.
Some studies have determined the sustainability of using crop residues for bioenergy while considering SOC levels in the European Union [1, 2]. Yet, the availability of agricultural residues depends on specific local conditions and the sustainable amount that can be removed is spatially-explicit [1]. A universal or too conservative threshold may deprive bioeconomy of an important feedstock.
Through the bioeconomy conversion, the easily degradable carbon ends in the main product and a more recalcitrant carbon is left in the co-products. This work aims to determine the sustainable amount of crop residues that can be used in different bioeconomy pathways (anaerobic digestion, gasification, pyrolysis, bioethanol production, hydrothermal liquefaction and bio-based materials production) when the carbon in the co-products is returned to maintain the SOC levels for the whole territory of France.

Approach and methods
Research question: What is the amount of crop residues that can be harvested from arable lands for different bioeconomy conversion pathways (anaerobic digestion, gasification, pyrolysis, hydrothermal liquefaction, fermentation to bioethanol, bio-based products) while maintaining or enhancing the SOC levels compared to a situation without harvest for bioeconomy?
It will study the potential of the conversion pathways to return part of the carbon from the harvested residues to arable lands (e.g. as digestate, biochar, molasses, etc.), and attempts to quantify how the conversion pathway affects the amount of crop residues that can be harvested maintaining the current SOC stocks.
A spatially explicit approach for the France territory will be applied. Spatial database (soils, climate, farming practices) will be used to create different cropping systems units. Soil carbon dynamics will be modeled using a carbon simulation software. The study will be relative and address each pathway against a baseline no-harvest case, by quantifying, over a long-term perspective, how much residues can be harvested in the bioeconomy case in order to achieve the same SOC level as the baseline case.

Results
We expect to determine the amount of crop residues that could be used for bioeconomy when considering the return of carbon from the conversion pathways to maintain the SOC levels on arable farms in France.

References:
1.Scarlat, N., et al., Integrated and spatially explicit assessment of sustainable crop residues potential in Europe. Biomass and Bioenergy, 2019. 122: p. 257-269
2.Monforti, F., et al., Optimal energy use of agricultural crop residues preserving soil organic carbon stocks in Europe. Renewable and Sustainable Energy Reviews, 2015. 44:p.519-529

17th September, 2020 | 17:45

Beike Sumfleth, Deutsches Biomasseforschungszentrum

EU Low iLUC Policy and Certification

Beike Sumfleth, Stefan Majer, Prof. Dr. Daniela Thrän
University of Leipzig
Grimmaische Str. 12
04109 Leipzig
Phone: +49 (0)341 2434-575
E-Mail: **beike.sumfleth@dbfz.de**

Relevance and aim: Future projections expect a growing bioeconomy (BE) and thus, an increasing demand for biomass (Delbrück et al. 2018). Certification can be an important safeguard mechanism to guarantee a certain level of sustainability. Appropriate criteria and indicators are needed for a sustainable development of the BE. However, leakage effects exist from incoherent sustainability policies for biomass, like indirect land use change (iLUC) effects (Majer et al. 2018). Those effects refer to shifts in land use induced by a change in the production level of an agricultural product elsewhere. These effects cannot be measured, why many of the existing approaches attempt to model the iLUC effects of biofuels (Woltjer et al. 2017) and biobased products. The results of this work also contributed to thedevelopment of a policy framework and the targets for the EU biofuel sector. As a consequence, the EU Renewable Energy Directive (RED) recast proposes a risk-based approach for the certification of biofuels. Following this rationale of the RED, low iLUC risk biomass could be obtained from so-called additionality measures. The aim of this presentation is to reveal how the potential application of the proposed additionality measures might be realised and verified in practice.

Methodology: Our approach bases on results of the STARProBio project, where we identified the most relevant parameters driving iLUC risks. Additionally, we analysed existing approaches for the certification and regional low iLUC risk assessment. Preliminary results: We identified five potential practices for low iLUC risk biomass production, which are likely to be used by market actors. Amongst others, these comprise increased crop yield and cultivation of unused land. This is in line with the additionality measures proposed by the RED. For both measures, we will present several approaches to determine the amount of low iLUC risk biomass in a product certification approach.

Next steps: In the next steps, the identified practices will be tested, amongst others with a Life Cycle Assessment (LCA) approach. This will be followed by the development of an indicator based low iLUC risk certification module.

References:
Delbrück, Sebastian; Griestop, Laura; Hamm, Ulrich (2018): Future Opportunities and Developments in the Bioeconomy. A Global Expert Survey. German Bioeconomy Council. Berlin. Majer, Stefan; Wurster, Simone; Moosmann, David; Ladu, Luana; Sumfleth, Beike; Thrän, Daniela (2018): Gaps and Research Demand for Sustainability Certification and Standardisation in a Sustainable Bio-Based Economy in the EU. In Sustainability 10 (7), p. 2455. DOI: 10.3390/su10072455. Woltjer, Geert; Daioglou, Vassilis; Elbersen, Berien; Ibañez, Goizeder Barberena; Smeets, Edward; González, David Sánchez; Barnó, Javier Gil (2017): Study Report on Reporting Requirements on Biofuels and Bioliquids stemming from the Directive (EU) 2015/1513: European Commission.

ORAL PRESENTATIONS

SESSION 2
SYSTEM ANALYSIS BIOENERGY

3RD DOCTORAL COLLOQUIUM BIOENERGY

17th September, 2020 | 16:30

Matthias Jordan, Helmholtz Centre for Environmental Research - UFZ

Modeling the future use of bioenergy in the German heat sector, under consideration of consumer preferences

Matthias Jordan, Charlotte Hopfe, Markus Millinger, Julian Rode, Prof. Dr. Daniela Thrän
University Leipzig
Grimmaische Str. 12
04109 Leipzig
Phone: +49 (0)341 2434 590
E-Mail: **matthias.jordan@ufz.de**

Biomass is the largest renewable energy contributor in the German heat sector today. However, the resource biomass is limited and a great share of the German yearly usable potential is already exploited. In the future, alternative renewable heat options will take up more market shares and the future role of bioenergy is unclear. The aim of our investigations is to determine possible least cost system pathways towards a renewable heat supply and determine the future role of bioenergy within these pathways. For this purpose, an energy system optimization model (ESOM) was set up for the German heat sector, optimizing the technological deployment between 2015 - 2050. Former scenario and sensitivity analysis with this model showed that the most robust use of biomass is found to be in the form of wood chips from residues and Miscanthus in (high temperature) industry applications.

ESOMs are widely used to inform policy about energy transition strategies. However, consumer heterogeneity and consumer behavior that deviates from economic rationality are rarely considered in ESOMs. Especially in the heat sector, which is not only from a technical view characterized by its heterogeneity, various stakeholders with different interests and investment preferences are in place. In this study, heat transition scenarios are analyzed, considering consumer choice to provide policy insights with a higher level of confidence.

First, a literature review identified survey-based empirical data on consumer investment preferences for residential heating systems in Germany. This data was integrated into the ESOM for the German heat sector, using established methods from literature and combining them with a novel approach for calculating indirect costs, representing non- economic preferences. Two scenarios were analyzed: A business as usual and an ambitious measures scenario. The results show that the integration of consumer heterogeneity and investment preferences leads to a higher diversity of technology market shares in the private household sector. Especially, log wood technologies gain higher market shares compared to former studies, indicating that a future demand for bioenergy in the private household sector will persist in certain scenarios and, in addition to former recommendations, biomass should not solely be considered for (high temperature) industry applications when designing policies. However, these findings need to be handled with care, since the empirical data basis is limited and the methodological approach is at an early stage.

17th September, 2020 | 16:55

Thomas Steiner, BEST - Bioenergy and Sustainable Technologies GmbH

Advanced modular process analysis tool for biomass-based Chemical Looping systems GmbH

Thomas Steiner, Kai Schulze, Robert Scharler
Graz University of Technology
Rechbauerstraße 12
8010 Graz
E-Mail: **thomas.steiner@best-research.eu**

In order to limit global warming to 1.5 °C compared to the pre-industrial temperature level, zero net CO_2 emissions are needed on a global scale until 2050. A Chemical Looping (CL) process represents a technological system which is CO_2-negative when using biomass as fuel and thus can substantially contribute to this target. In principle, the process uses a metal oxide as oxygen carrier material (OC) which is cyclically oxidized by air or steam and reduced by the fuel. Without air as the direct oxygen source for fuel conversion, high calorific product gases or pure carbon dioxide in case of combustion are obtained after the condensation of water vapor, which can then be stored or further utilized.

Within the funded project ”BIO-LOOP”, different Chemical Looping processes (for example combustion, gasification, hydrogen production) and reactors (fixed bed, fluidized bed) are investigated numerically and experimentally. An advanced process analysis tool based on mass and energy balances of the system considered will be presented. It provides data about the specific internal and external streams, process conditions and efficiencies. Within the analysis tool, various independent modular units describe individual process steps, e.g. mixing, chemical reaction or splitting. These components can be adjusted, combined and interconnected according to the flow chart of the system. The process model represents the first step towards a flexible Chemical Looping reactor simulation toolbox to analyze various process scenarios. Emphasis is put on the flexibility regarding the fuels and oxygen carriers, their conversion and possible process variations. The tool developed will support upcoming CFD modeling and further economic considerations.

17th September, 2020

Katharina Scherge, Leuphana University Lüneburg

Follow-up concepts for agricultural biogas plants – a techno-economic evaluation

Katharina Scherge, Heinrich Degenhart
Leuphana University Lüneburg
Universitätsallee 1
21335 Lüneburg
Phone: +49 (0)157 55796348
E-Mail: **scherge@leuphana.de**

The EEG 2000 stipulated a minimum remuneration for a period of 20 years to biogas plants (BGPs). Therefore, the guarantee period for the first plants expires in 2020/2021. Further operation of existing BGPs should be analyzed regarding the aspects technical feasibility and economic efficiency. Operators face the challenge of having to make highly complex decisions about follow-up investments. Within the frame of this PhD thesis, an evaluation of the value of investment decisions for agricultural biogas plants with the real options approach according to Stewart C. Myers is aimed to solve these valuation problems for follow-up concepts.

Approach and methods

A combined technical and economic analysis using the real options approach will be used. The fundamental applicability of the real options approach for the evaluation of investment decisions of BGPs will be examined. In the evaluation, a distinction can be made between analytical and numerical methods. The binomial model (numerical) seems suitable for the evaluation of investment decisions for BGPs. It is considered having simpler mathematical requirements and a high degree of transparency and comprehensibility for the user. A model, which combines technical and economic aspects based on an average German BGP has to be built.

Interim Results

Data about the current stock of German BGPs and possible follow-up concepts was collected [1]. Different follow-up concepts like flexibilisation of the power production, gas treatment, heat utilization, digestate treatment and ecosystem services provided by BGPs were identified and the necessary technological changes (and related investments) examined. It was found that an economical evaluation using the real options approach makes sense due to the „option character“ of the decisions to be made. Different options can be evaluated considering the flexibility created by dynamic decisions taken by farmers. Other determining factors of real investment projects like exclusivity and irreversibility were identified in investment decisions for BGPs.

Outlook

By using the real options valuation, a technical and economic analysis will take place. Through this procedure, different investment decisions for BGPs will be transparently presented and subsequently evaluated. Thus, the possibilities (i.e. option values) that arise after each investment step are shown and quantified. The aim is to carry out a comparative analysis and evaluation of follow- up concepts for further operation.

References:
[1] NxtGenBGA (FKZ 22407217); Scherge, Holstenkamp: Auswahl- und Bewertungsprozess für Post-EEG-Konzepte und Bewertungskriterien im Rahmen des Projektes NxtGenBGA. In: Biogas in der Landwirtschaft - Stand und Perspektiven. FNR/KTBL Kongress: 09/2019. Leipzig, 398-391; In preparation: Güsewell, Scherge et al.: Extending the operation of existing biogas plants

17th September, 2020 | 17:45

Niels Kirstein, Deutsches Biomasseforschungszentrum

Development and Current Status of Solid Biofuel Markets in the European Union

Niels Kirstein[1], Prof. Dr. Daniela Thrän[1,2]
Leipzig University
Grimmaische Str. 12
04109 Leipzig
Phone: +49 (0)341 2434-601
E-Mail: **niels.kirstein@dbfz.de**

[1] DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Str. 116, 04347 Leipzig

[2] Helmholtz-Zentrum für Umweltforschung GmbH – UFZ, Department Bioenergie (BEN)
Permoserstraße 15, 04318 Leipzig

Solid biogenic fuels are the most relevant renewable energy sources (RES) on a global basis. Their utilization ranges from combustion in traditional fireplaces, to the application in modern conversion plants of varying capacity. In 2018, they contributed with more than 40% to the energy consumption from RES and with 6% to the total energy consumption of the European Union (EU).

Solid biofuels are covering a wide spectrum of different raw materials, whereby biomass from forestry and the wood processing industry constitutes the major part. Additionally the feedstock can originate from agricultural residues or by-products. Due to their diverse origin, solid biofuels may comprise a great diversity concerning their physical and chemical characteristics, benefitting energetic purposes to different degrees. Thermochemical conversion processes enable their transformation into energy carriers with improved qualities with regard to energy density, storability, flexible application and related emissions.

The majority of scientific studies on the utilization of solid biofuels are focusing on single fuel types or associated conversion technologies, but a comprehensive comparison of the characteristics of the different energy carriers, their fields of application and resulting energy market perspectives on a European level is lacking. Therefore, this study uses literature review and database evaluations to present the development and current status of solid biofuel utilization in the EU. It displays the variety of solid biofuels, giving an overview on their range, quality assortments and existing standards. Databases were used to evaluate solid biofuel trade, sectors of application and their contribution to the European energy supply system between 1990 and 2018. These data have been analyzed for the whole EU as well as each member state, revealing varying usage patterns and application in different energy markets and commercial sectors.

The study allows to derive key factors for the development of solid biofuel markets. It is laying the ground for further investigations addressing the development of solid biofuels until 2050 and their role in a carbon neutral European Union.

POSTER PRESENTATIONS

SESSION 3
BIOCHEMICAL CONVERSION

3RD DOCTORAL COLLOQUIUM BIOENERGY

18th September, 2020 | 10:00 - 11:00

Felipe Borim Corrêa, Helmholz-Centre for Environmental Research – UFZ

Genome-resolved metagenomics sheds light on the anaerobic conversion of aromatics by complex communities

Felipe Borim Corrêa, Samuel Eziuzor, Shuchan Peng, Júnia Schultz, João Pedro Saraiva, Lorenz Adrian, Peter Stadler, Sabine Kleinsteuber, Carsten Vogt, Ulisses Nunes da Rocha
University Leipzig
Augustusplatz 10
04109 Leipzig
E-Mail: **felipe.correa@ufz.de**

Anaerobic conversion of organic compounds is one of the key points in bioenergy production. Because of that, the discovery of novel microorganisms and their enzymes that have degradation capabilities are of great value for improving the research on biofuel production. Lately, the recovery of metagenome- assembled genomes has become a common approach to explore microbial communities. Metagenomics coupled with cutting edge bioinformatics allows the recovery of near- complete genome sequences the functional potential of which can be individually investigated. This combined with metaproteomics can indicate which metabolic pathways are actually active in the microbial community.

Here, we use anaerobic benzene degradation as a model to explore functional and genomic aspects of the conversion of aromatics. A community mineralizing benzene under nitrate-reducing conditions has been maintained in laboratory microcosms for over a decade. A previous study with this community revealed its taxonomic profile, however, no genetic information on functional capacity was determined.

Our model microbial community was grown in batch cultures containing 13C-labeled benzene as sole carbon source and nitrate as electron acceptor. We performed whole metagenome sequencing at five sampling times from solid and liquid phases in triplicates: experiment set up (T0), beginning of mineralization (T1), early log-phase (T2), late log-phase (T3) and end of experiment (T4). The metagenomes were processed with MetaWRAP for the recovery of metagenome-assembled genomes and assigned to the GTDB-Tk taxonomy. Genomes assigned to the same taxon were placed into groups and the Average Nucleotide Identity (ANI) was calculated to measure the distances between these genomes and divide them into subgroups.

As a result, we recovered 2670 good quality metagenome-assembled genomes (contamination <10%) spanning 212 bacterial and 4 archaeal unique taxa. ANI distances analysis showed that this community comprises 294 bacterial and 4 archaeal species based on the species level threshold of 95% ANI. To validate these groups, we are implementing a bootstrapping approach, which will potentially subdivide those 298 species at strain level. Currently, we are linking the metaproteomics data with the recovered metagenome-assembled genomes to identify the key players in the degradation process.

This together with the strain investigation will allow us to search for different functional capacities in different strains of the same species.

In conclusion, using temporal experimental design and metagenomics we recovered 2670 near-complete metagenome assembled genomes distributed in over 300 different species in from a complex microbial community. Our study provides information on key players and enzymes involved in this anaerobic conversion process. Such an approach applied to bioenergy studies can help increase the repertoire of novel enzymes and microorganisms that can improve biofuel production.

Genome-resolved metagenomics sheds light on the anaerobic conversion of aromatics by complex communities

Felipe Borim Correa[1,2], Samuel Eziuzor[3], Shuchan Peng[3,4], Júnia Schultz[1,5], Joao Pedro Saraiva[1], Lorenz Adrian[6], Peter F Stadler[2], Sabine Kleinsteuber[1], Carsten Vogt[3], Ulisses Nunes da Rocha[1,7]

[1]Helmholtz-Centre for Environmental Research, Department of Environmental Microbiology
[2]University of Leipzig, Department of Computer Science and Interdisciplinary Center of Bioinformatics
[3]Helmholtz-Centre for Environmental Research, Department of Isotope Biogeochemistry
[4]Chongqing University, Department of Environmental Science
[5]Universidade Federal do Rio de Janeiro, Departamento de Microbiologia Geral
[6]Helmholtz-Centre for Environmental Research, Department of Environmental Biotechnology

ulisses.rocha@ufz.de*
@UlissesRocha13*

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

UFZ HELMHOLTZ Centre for Environmental Research

Motivation

Anaerobic conversion of organic compounds is one of the key points in bioenergy production. The discovery of novel microorganisms and their enzymes that have degradation capabilities are of great value for improving the research on biofuel production. Metagenomics coupled with cutting edge bioinformatics allows the recovery of near-complete genome sequences whose functional potential can be individually investigated.

Objectives

We aimed to use anaerobic benzene degradation (ABD) as a model to explore functional and genomic aspects of the conversion of aromatics.

Methods

- The microcosms were inoculated with our community and fed with labeled benzene (25% ^{13}C) at the beginning of the experiment. Solid (sand) and liquid phases were sampled at five time points (Figure 1).
- DNA was extracted and metagenomes were shotgun-sequenced with ~30 million reads per library.
- Metagenome-assembled Genomes (MAGs) were recovered using MetaWRAP [1] and taxonomies were assigned with GTDB-Tk v0.3.3 [2].
- Subspecies were determined from ANI distances between genomes and the best quality genomes were picked as representatives (Figure 2).
- Abundance of representative MAGs in each sample was estimated by mapping metagenomic reads to recovered genomes and classic diversity analyses were performed.

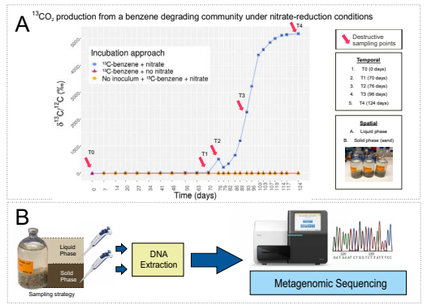


Figure 1. Sampling schema by using $^{13}CO_2$ as indicator of microbial activity in five time points and sampling design (A). Experimental design for DNA extraction and sequencing (B).

Results

- We recovered 2670 metagenome-assembled genomes (completeness - 5 * contamination > 50) spanning 212 bacterial and 4 archaeal unique taxa.
- The determination of subspecies resulted in 362 groups of microbial subspecies from which one high-quality representative per group was picked.
- NMDS ordination showed that samples are more simillar towards end of the experiment (Figure 3 B).

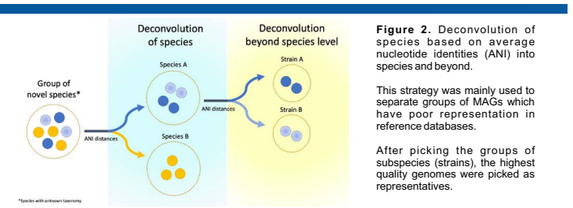


Figure 2. Deconvolution of species based on average nucleotide identities (ANI) into species and beyond.

This strategy was mainly used to separate groups of MAGs which have poor representation in reference databases.

After picking the groups of subspecies (strains), the highest quality genomes were picked as representatives.

*Species with unknown taxonomy

Results: continuation

- The temporal variation of bioindicators suggests which organisms might be the key players key in the ABD process (Figure 4).

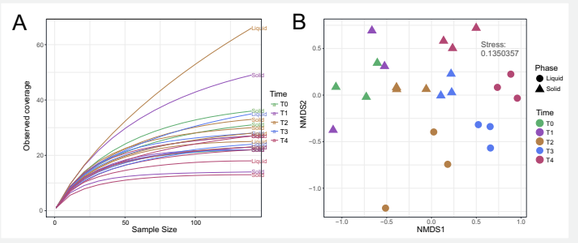


Figure 3. (A) Rarefaction curves of the observed representative MAGs per sample post rarefaction. (B) NMDS ordination plot. That last time points T3 and T4 might indicate enrichment and lower diversity.

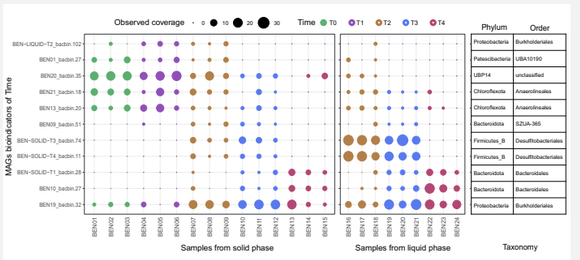


Figure 4. Bubble chart with the abundance in coverage of top 11 bioindicators for "time" measured by Mean Decrease Gini (MDG) using Random Forest regression. The top 11 were selected by keeping bioindicators which MDG summed with the last element was greater than 0.5.

Conclusion

- The temporal variation of the bioindicators suggests that synergistic interactions are necessary for anaerobic benzene degradation using nitrate as terminal electron acceptor.
- Our succession experiment coupled with genome-resolved metagenomics enabled the recovery of 2670 near-complete metagenome assembled genomes distributed in 362 different subspecies from a complex microbial community.
- Potential key players were defined however the identification of the genetic potential must be performed to draw clearer conclusions.
- We are currently investigating what microbes have the enzymes involved in that process. This task will be performed with a tool developed by our group tool OrtSuite (http://github.com/mdsufz/OrtSuite).

References

1. Uritskiy, Gherman V., Jocelyne DiRuggiero, and James Taylor. "MetaWRAP—a flexible pipeline for genome-resolved metagenomic data analysis." Microbiome 6.1 (2018): 158.
2. Chaumeil, Pierre-Alain, et al. "GTDB-Tk: a toolkit to classify genomes with the Genome Taxonomy Database." Bioinformatics (2019).

HIGRADE

18th September, 2020 | 10:00 - 11:00

Daniel Dzofou Ngoumelah, Deutsches Biomasseforschungszentrum

Interaction between electroactive biofilms and anaerobic digestion effluents

Daniel Dzofou Ngoumelah, Falk Harnisch, Jörg Kretzschmar
Leipzig University
Grimmaische Str. 12
04109 Leipzig
Phone: + 49 (0)341 2434-376
E-Mail: **daniel.dzofou.ngoumelah@dbfz.de**

Anaerobic digestion (AD) and microbial electrochemical technologies (MET) can be combined in manifold ways, e.g., for removal of monovalent ions, effluent polishing, electrochemical biogas upgrading and sensor applications. However, recent studies showed negative influences of AD effluents on the performance of pre-grown Geobacter sp. dominated biofilms. Therefore, the aim of this study was to investigate if Geobacter sp. dominated biofilms can be adapted to AD environments and, if the biofilm age as well as the presence or activity of methanogens affects the biofilm stability.

To answer these questions, we performed several shock and adaptation experiments using AD effluents in different concentrations (10% - 100%) and biofilms of different age. The activity methanogens was inhibited by application of 50 mM 2-BES, their presence was minimized by filtration of the AD effluent (0.2 µm pore size).

Old biofilms (pre-grown for > 5 weeks) showed higher resilience during shock experiments with AD effluents compared to young biofilms (< 3 weeks). Adaption of biofilms failed for a yet unknown reason whereas the application of 2-BES as well as filtration of the AD effluent had positive effects on the activity and resilience of pre-grown biofilms.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

INTERACTION BETWEEN ELECTROACTIVE BIOFILMS AND ANAEROBIC DIGESTION EFFLUENTS

Daniel N. Dzofou[1,2], Falk Harnisch[2], Jörg Kretzschmar[1]

MOTIVATION

Anaerobic digestion (AD) and microbial electrochemical technologies (MET) can be combined in manifold ways, e.g., for removal of monovalent ions, AD effluent polishing, electrochemical biogas upgrading as well as AD sensor applications. However, recent studies showed negative influences of AD effluents on the performance of microbial electrochemical sensors (MESe) in AD reactors. Therefore, the aim of the study was to investigate how Geobacter spp dominated electroactive biofilms that form the receptor of the MESe, interact with effluents for AD reactors and if the biofilm age as well as the presence or activity of methanogens affects the biofilm stability.

MATERIAL AND METHODS

- **Setup**: Single chamber microbial electrolysis cell MEC (V=250 mL), three electrode arrangement using graphite-rod electrodes and Ag/AgCl sat. KCl reference electrodes (RE), T=38° C, n=3.
- **Growth medium**: 50 mM phosphate buffer incl. vitamins, trace elements and acetate as sole carbon source.
- **Biofilm**: *Geobacter* spp. dominated biofilm anodes
- **Techniques**: Chronoamperometry (CA) at 0.2 V vs. RE

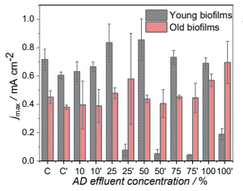
EXPERIMENTS

Name of the experiment	Age of the biofilms / weeks	AD effluent concentration in the growth media / % (v/v)	New biofilms for each AD effluent concentration	Duration / batch cycles (weeks)
A	3 (young)	10, 25, 50, 75, 100	Yes	2
B	5 (old)	10, 25, 50, 75, 100	Yes	2
C	5 (old)	10, 25, 50, 75, 100	No	2
D	5 (old)	50	No	4
E	5 (old)	50	No	5

Table 1: Names and parameters of the performed sets of experiments: (A) AD shock young, (B) AD shock old, (C) AD adaptation, (D) 2-Bromoethanesulfonate (2-BES), (E) Filtration

RESULTS

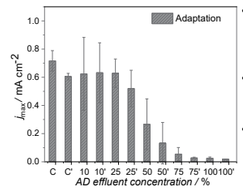
- Young vs old: The effect of age on biofilm resilience in AD effluents



- Experiments with young biofilms induced gradual detachment of the biofilm from the anode, which led to a significant decrease in biofilm activity (maximum current density j_{max}) from the second week onwards, in contrast to the experiment with old biofilms, where j_{max} remains constant for two weeks.

Figure 1: j_{max} during shock experiment with young and old biofilms, Error bars indicate confidence interval (CI). C: AD effluent free control, ': second week.

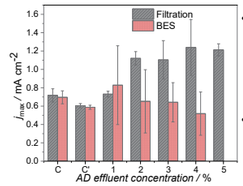
- Adaptation: increasing resilience of old biofilms in AD effluents



- Stepwise exposition of old biofilms to increasing concentrations of AD effluent showed stable j_{max} when using 10% and 25% AD effluent
- AD effluent concentrations > 25 % cause decrease of biofilm activity and detachment of biofilms
- Methanogens, solid mineral particles or dissolved compounds may cause the observed interferences also observed in Figure 1.

Figure 2: j_{max} during adaptation experiment, Error bars indicate CI. C: : AD effluent free control, ': second week.

- Methanogens and solid particles effect on electroactive biofilm



- Experiments with application of 50 mmol L^{-1} 2-BES (inhibits activity of methanogens) or filtration of AD effluent (pore size 0.2 µm) show constant j_{max} values over 4 - 5 weeks.
- Using 2-BES or filtration of AD effluent induced stabilization of biofilm activity.

Figure 3: $j_{[max]}$ during filtration and 2-BES application, Error bars indicate CI. C: : AD effluent free control, ': second week.

CONCLUSION

The study shows that old *Geobacter* spp. dominated biofilms are more resilient towards AD effluents compared to young biofilms, probably due to a more pronounced protective layer of microorganism on the outer layers of the biofilms. Inhibition of methanogens using 2-BES or filtration to remove solid particles in the AD effluent induce increased resilience of Geobacter spp.dominated biofilms

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Contact: Daniel.Dzofou.Ngoumelah@dbfz.de | Phone: +49 (0)341 2434-376

[1] DBFZ, Biochemical Conversion Department, Process Monitoring and Simulation, Torgauer Straße 116, 04347 Leipzig
[2] UFZ, Environmental Microbiology Department, Electrobiotechnology, Permoserstraße 15, 04318 Leipzig

DBFZ UFZ

18th September, 2020 | 10:00 - 11:00

Jerome Undiandeye, Deutsches Biomasseforschungszentrum

Biomethane Potential of Ensiled Sugar Beet Leaves and Cassava Leaves

Jerome Undiandeye, Walter Stinner, Heike Straeuber, Mathias Stur, Bengt Verworner
University Rostock
Justus-von-Liebig-Weg 6
18059 Rostock
E-Mail: **jerome.anguel.undiandeye@dbfz.de**

Ensiling has been used extensively as a cheap and effective method of preserving wet biomass. This makes it possible to overcome seasonal generation of mass-flows and to make ensiled materials available whenever needed. Sugar beet leaves, a by-product of sugar beet cropping is an easy degradable agricultural residue in moderate climate zones. Due to its low dry-matter content, there is the option of co-ensiling with lignozellulose biomasses like straw. However, with Germany currently producing about 30 million tons of sugar beet every year, there is the need to increase the usage of the leaves. Since these leaves are only available during harvest, there is the need to preserve them for at least one year, by a cheap means, in order to make them available all-ye-ar- round. Like sugar beet leaves, cassava leaves are also not being fully utilized.

With Nigeria being the highest producer in the world, there is a huge potential for the utilization of the leaves in biogas production. In this study, the properties of sugar beet leaves were studied over a 370 day period of ensiling at room temperature and at 80 °C, and then tested for its biomethane potential. Cassava leaves, airtight sealed for only a period of 7 days in this study, were also tested for its biomethane potential. Method. In order to determine if the method of harvesting affect the efficiency of ensiling and biomethane potential, the sugar beet leaves were harvested by hand and by the use of machine mid of October. These leaves were then ensiled, with and without additive (homofermentative lactic acid bacteria) in air-tight bags of dimension 300 mm × 200 mm at 80 °C.

The samples in the air-tight bags were of three types; hand-harvested sugar beet leaves, machine-harvested sugar beet leaves, and machine-harvested sugar beet leaves with additives. An additional ensiling storage of minced material from maschine harvest without additives was done in vertical columns of height 3.60 m at room temperature. This was to determine the effect of room temperature on the quality of ensiling and biomethane potential as compared to a lower temperature of 80 °C. Samples for analysis from the vertical columns were taken from five different points of 3.40, 2.60, 1.87, 1.00 and 0.20 m. Two models were used to study the kinetics of the biomethane potential. Results. The pH in the air-tight bags were in the range of 4.31- 4.43 and 4.08 – 4.34 in the vertical columns. Butyric acid was below detectable limit in all the silages. The quality of ensiling was not significantly affected by the method used in harvesting the sugar beet leaves. The biomethane potential obtained in all the silages were high. The first order kinetic model was a better fit for the results. Conclusions: Sugar beet leaves can be adequately ensiled in wet form at room temperature for a whole year and then use for biomethane production irrespective of the method used for harvesting.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

KINETICS OF THE BIOMETHANE POTENTIAL (BMP) OF CASSAVA AND SUGAR BEET LEAVES.

Undiandeye, Jerome [1]; Weinrich, Sören [1]; Stur, Mathias [1]; Heike, Sträuber[2]; Nelles, Micheal[1,3]; Stinner, Walter [1].

WHY CASSAVA LEAVES? WHY SUGAR BEET LEAVES?

In 2018,

- **17.4 million tons of sugar beet leaves were generated in Germany**
- **6.7 million tons of cassava leaves were generated in Nigeria**

Figure 1: Left; A heap of Sugar beet leaves and Right; Cassava Leaves in a Cassava Farm in Nigeria.

MATERIALS AND METHODS

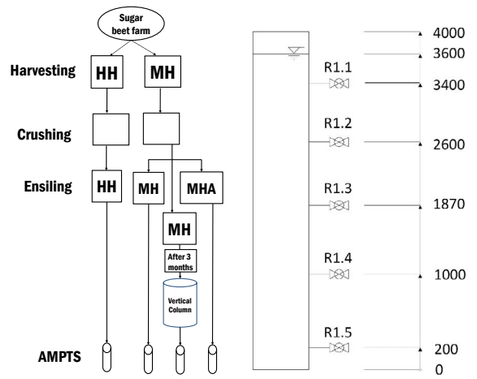


Figure 2: Left - Research Procedure (SL sugar beet leaves, HH handharvested SL, MH machine-harvested SL, MHA machine-harvested SL with additives); Right - Schematic diagram of the silo used for ensiling (dimensions in mm)

- Sugar beet leaves were harvested from a farm in Saxony.
- Three species of cassava leaves; TMS 30001, TMS 30555 and TMS 30572 from Nigeria were used.
- The sugar beet leaves were ensiled for 370 days.
- The AMPTS II (Bioprocess Control, Sweden) was used to determine the BMP of the substrates.
- The inoculum used was harvested from an active biogas plant in DBFZ. The plant uses maize silage as substrates.
- Four kinetic models were used to predict the biomethane potential of the substrates.

RESULTS AND CONCLUSION

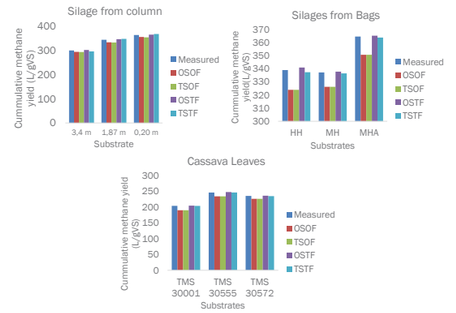


Figure 3: Measured and predicted methane yields of the substrates (OSOF One-step one-fraction first-order kinetic model, TSOF Two-steps one-fraction first-order kinetic model, OSTF One-step two-fractions first-order kinetic model, TSTF Two-steps two-fractions first-order kinetic model)

Sugar beet leaves can be ensiled at room temperature for biogas production. The BMP of the sugar beet silage in the column increased with depth from the top of the column, reaching a maximum of 364±20 L/gVS at the 0.20 m height. The method of harvesting has no effect on the BMP of the sugar beet silage. The additive used in this study increased the BMP of sugar beet silage by 8%. For the cassava leaves, TMS 30555 had the highest BMP of 260±9. The effective biogas production period varied between 5 and 10 days for the sugar beet leaves, and between 12 and 16 days for the cassava leaves. The two-steps two-fraction first-order kinetic model (TSTF) described the methane yield better than the other models. This was seen in the highest value of R^2 as well as in the lowest values of root-mean square error (RMSE), Akaike information criterion (AIC) and the Bayesian information criterion (BIC).

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartner: Jerome Undiandeye | E-Mail: jerome.anguel.undiandeye@dbfz.de
[1] German Biomass Research Centre, Department of Biochemical Conversion, Leipzig
[2] Helmholtz Centre for Environmental Research, Department of Environmental Microbiology, Leipzig.
[3] Faculty of Agricultural and Environmental Sciences· Department of Waste and Resource Management, University of Rostock·

18th September, 2020 | 10:00 - 11:00

Jan Sprafke, University Rostock

Continuous anaerobic digestion of biowaste and co-substrates

Jan Sprafke, Niklas Lajewski, Dr. Andrea Schüch, Prof. Dr. Michael Nelles
University of Rostock
Justus-von-Liebig-Weg 6
18059 Rostock
Phone: +49 (0)381 4034994
E-Mail: **jan.sprafke@uni-rostock.de**

The difficulty in estimating the amount of biogas from anaerobic biological biowaste treatment consists of not only the influence of the seasonally fluctuating waste quality but also of the incongruent addition of co-substrates, whose influence on and interaction with the fermentation process is not or only insufficiently described in the scientific literature.

The aim of the experiments of the university of Rostock was to investigate the influence of agricultural and industrial residues on the metabolic processes of anaerobic digestion. To check the influence an eight-week trial period was set for the continuous monofermentation of biowaste compared with the fermentation of biowaste with co-sunstrate. In order to determine the influence of the loading rate per unit volume, the substrate supply was gradually increased every two weeks. The co-substrate proportion in the substrate input remained constant in the trial and was between zero percent and 13 percent depending on the test group. The fresh matter input was identical in each process stage.

The evaluate parameters are dry residue, organic dry residue, degree of degradation, pH-value, VOA/TAC and specific biogas yield.

The chosen investigation methodology allows the comparison between biowaste mono- fermentation and co-fermentation under mesophilic conditions. Increased dry matter content in the fermenter has been observed when using Kaff as co-substrate. This increased dry matter content can lead to an increased process water requirement in practice plants. A lower dry matter content compared to mono-fermentation was found in the co-fermentation of ketchup, which would result in a reduced process water requirement. Volatile organic acids, buffer capacity and VOA/TAC value are within normal ranges.

The pH-value in all fermenters is slightly increased, but the value is in the usual range limits of normal plant operation.

Based on the results, the use of co-substrates and the associated effects on the technical operation management can be better explanined and the effectiveness of the anaerobic digestion of biowaste can be optimised, especially in the context of the planning and operation of anaerobic biowaste treatmentplants.

Continuous anaerobic digestion of biowaste and co-substrates

Jan Sprafke, Niklas Lajewski, Andrea Schüch, Michael Nelles

Introduction
The aim of the experiments was to investigate the influence of agricultural and industrial residues on several process parameter of anaerobic digestion of biowaste and biowaste mixtures.
To check the influence, an eight-week trial period was set for the continuous monofermentation of biowaste compared to the co-fermentation of biowaste with two co-substrates from industrial (ketchup) and agricultural (chaff) origin.

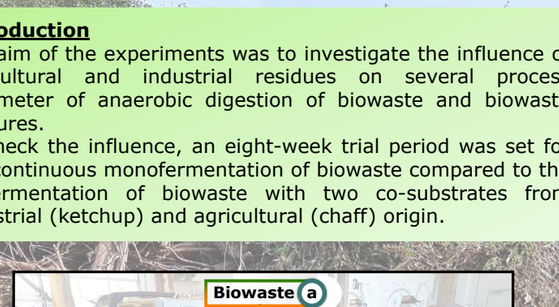


Fig.3: Gas yield of volatile solids

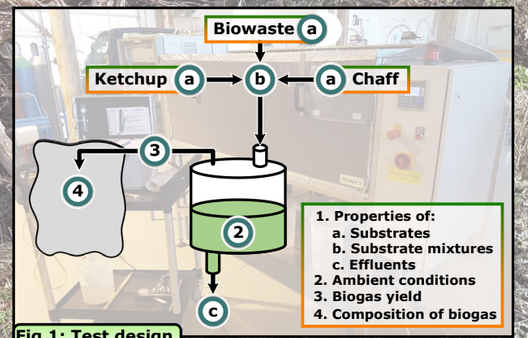


Fig.1: Test design

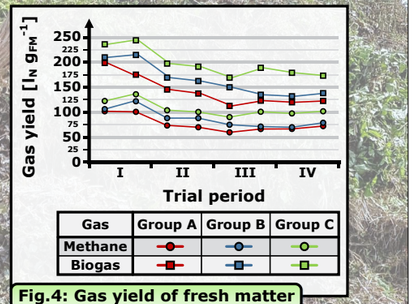


Fig.4: Gas yield of fresh matter

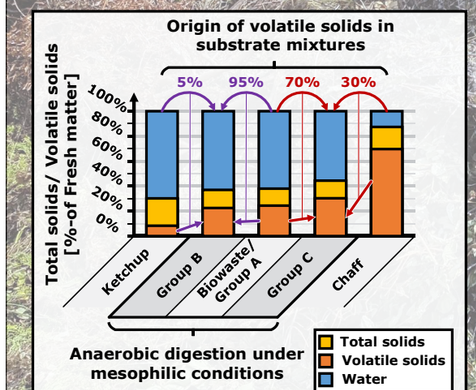


Fig.2: Properties of biowaste and biowaste co-substrate mixtures

Tab. 1: Process parameters under stable conditions

Parameter	Group A	Group B	Group C
FOS [mg/l]	2 765	2 905	3 192
TAC [mg/l]	13 473	13 145	14 057
FOS/TAC	0.21	0.22	0.23
pH-value	7.92	8.01	7.98

Results
The results show that the selection of co-substrates is essential for an optimised plant operation.
Liquid and solid co-substrates have similar influences on process parameters like pH, FOS, TAC and FOS/TAC.
The specific gas yields of the biowaste co-substrate mixtures exceed the gas yield of the biowaste monofermentation.

NETZ-STABIL | AG Bioenergieanlagen und Speicher – AG Sektorkopplung
Deoartment of Waste and Resource Management
Universität Rostock | Tannenweg 22 | Justus-von-Liebig-Weg 6 | 18059 Rostock

18th September, 2020 | 10:00 - 11:00

Andreas Gantenbein, Paul Scherer Institute

Flexible Application of Biogas Upgrading Membranes in Power-to-Methane Processes

Andreas Gantenbein, Julia Witte, Oliver, Kröcher, Serge M.A. Biollaz, Tilman J. Schildhauer
École polytechnique fédérale de Lausanne
Forschungsstrasse 111
5232 Villigen PSI
E-Mail: **andreas.gantenbein@psi.ch**

Biogas, a mixture of methane and CO_2, has to be upgraded before biomethane can be injected into the gas grid due to the quality specifications (>96% CH_4, <4% CO_2, <2% H_2 in Switzerland). The CO_2 can either be separated or converted to additional methane. This direct methanation of biogas enables the use of renewable CO_2 for power-to-gas operation for seasonal storage of electricity in the natural gas grid. The process was demonstrated using a 10 kWSNG pilot plant, based on bubbling fluidized bed methanation [1]. In order to comply with grid requirements, separation and recycle of residual hydrogen and CO_2 is necessary. Witte et al. [2] showed that gas separation membranes could provide an economic solution to reach these requirements In this work, we show that a commercial polymeric membrane (Evonik Sepuran) can be used for both, biogas upgrading by CO_2 separation and for H_2 recycle in direct methanation of biogas. Experiments have shown that the biomethane produced in direct methanation still contains up to 11% H_2 and 2% CO_2 due to thermodynamic equilibrium. Therefore, the experiments were performed with the focus of decreasing the H_2 and CO_2 down to the required limits, on the one hand, and on upgrading a gas mixture representing fermentation-derived biogas (40% CO_2 / 60% CH_4), on the other hand. The membrane unit was installed in the PtG demonstration unit and placed in a water bath, in order to maintain a stable temperature (20-40°C). The inlet and outlet streams of the membrane were monitored regarding their composition (micro-GC) and flow rates. The pressure of the system was controlled on the retentate side (product gas) of the module. The permeate (recycle) was kept at ambient pressure. The experimental data showed that the injection limitations could be reached in both operation modes, H_2 and CO_2 removal, in a single step at a pressure level suitable to the methanation reactor. However, in case of upgrading by CO_2 separation, a second separation step in the recycle stream is required in order to limit the methane emissions from the plant. From the data, an upgrading concept was derived which allows fast switching between biogas and biomethane upgrading. This dual-use concept of membranes allows the injection of methane during the whole year, while using the direct methanation unit only in times when renewable hydrogen is available. The proposed concept includes only identical, commercially available CO_2 separation membranes, which limits the complexity of the system and has therefore a positive impact on the cost. This is especially favourable for small-scale biogas plants with grid injection. Using the dataset obtained in these experiments, a counter current unit model of the membrane was developed, which is used for performance prediction and optimization in the techno- economic analysis of the process chain.

[1] Witte J. et al., Appl. Energy, 2019, 240, 359- 371

[2] Witte J. et al., Energy Convers. Manage., 2018, 178, 26-43

biosweet
Biomass for Swiss Energy Future
Swiss Competence Center for Energy Research

PAUL SCHERRER INSTITUT PSI

In cooperation with the CTI
Energy funding programme
Swiss Competence Centers for Energy Research
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Commission for Technology and Innovation CTI

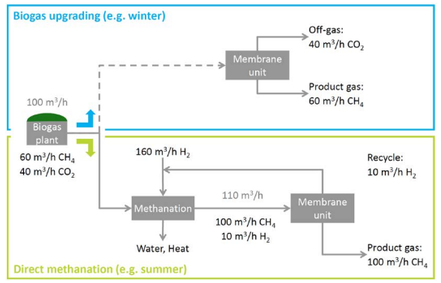
Flexible Application of Biogas Upgrading Membranes for Hydrogen Recycle in Power-to-Methane Processes

Andreas Gantenbein, Julia Witte, Oliver Kröcher, Serge M. A. Biollaz, Tilman J. Schildhauer*
Paul Scherrer Institute (PSI), Energy and Environment Division, CH-5232 Villigen PSI, Switzerland

- Commercial biogas upgrading membrane module serves for H_2-recycle in a methanation pilot plant (TRL 5)
- Membrane-based upgrading concept allows fast switching between biogas upgrading (CO_2 removal) and PtG operation (H_2 recycle)
- Systematic study of operation parameters: pressure, temperature, flow rates, concentration ranges (H_2 & CO_2), co- & counter-current operation

Introduction

Direct methanation of biogas is a way to increase the yield of biomethane obtained from grid-injecting biogas plants. There are two major drawbacks:
- Catalytic methanation does not reach grid injection quality, due to thermodynamic limitation at elevated temperature.
- Temporarily high prices of renewable electricity might render the underlying power-to-gas (PtG) process uneconomic (e.g. during winter).



Concept with increased flexibility

Direct methanation of biogas (H_2-recycling) and CO_2 sequestration from biogas require both gas separation steps, which can be realised with membrane technology. By combination of both upgrading tasks in a single membrane unit, the operation mode of the biogas plant can be changed quickly, according to the situation at the energy market regarding renewable electricity.

Methods

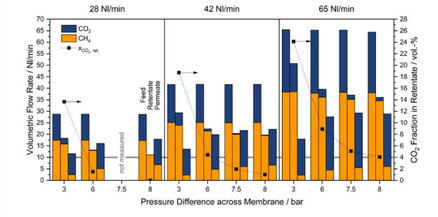
- Evonik Sepuran hollow fibre membrane module installed in a bubbling fluidised bed methanation pilot plant (10-20 kW)
- Characterisation of the separation performance by measurement of permeate and retentate gas flows and compositions
- Multiple feed gas compositions were tested at various pressures and flow rates simulating biomethane and biogas upgrading
- Membrane module was placed in temperature-controlled water bath to ensure isothermal conditions

Conclusions

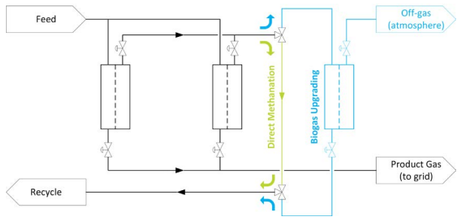
→ In both separation tasks, grid injection limitations could be reached at relevant pressure levels in a single step
→ Better quantitative understanding of the influence on the separation performance, such as temperature, pressure and flow rates
→ Increasing the temperature leads to higher permeability, but lower selectivity
→ Combined upgrading concept may reduce investment costs of grid injection plants and increase the overall biomethane yield
→ Flow rates can be increased by adding modules in parallel to the set-up

Results: Biogas Upgrading

Target: Fulfil grid injection limitations (> 96% CH_4, < 4% CO_2) and reduce methane emissions to atmosphere



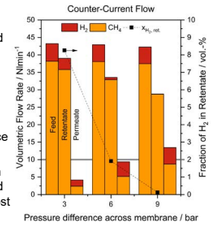
- Grid injection limitations could be fulfilled at Δp > 6 bar at 42 Nl/min
- Increased feed flow rates resulted in higher required Δp to fulfil 4%-limit
- Higher feed flow rate did hardly affect CH_4 concentration in permeate
- Higher Δp resulted in better separation of CO_2 from CH_4, but also higher permeate flow, therefore higher recycling flow
- One further step required to remove CO_2 (off-gas) from recycle stream. Minimisation of CH_4 emissions can be achieved by high flow rate, low Δp and decreasing the temperature (data not shown)



Results: Direct Methanation

Target: Fulfil grid injection limitations (< 2% H_2) and feed permeate back to reactor feed stream

- Gas quality for grid injection reached with single membrane module
- Grid injection limitations could be fulfilled at Δp > 6 bar at 42 Nl/min
- Co- and counter-current operation tested. Counter-current operation showed better performance (co-current data not shown)
- Higher pressure difference results in higher retentate purity, but increased recycle flow and higher operation cost



A. Gantenbein et al., *Chem. Eng. Sci.*, **2020**, 116012. doi:10.1016/j.ces.2020.116012

*) Corresponding Author: tilman.schildhauer@psi.ch | www.sccer-biosweet.ch | 28.08.2020

18th September, 2020 | 10:00 - 11:00

Fatih Gökgöz, Deutsches Biomasseforschungszentrum

Operational strategie for biogas plants with electricity and fuel supply

Fatih Gökgöz
University Rostock
Justus-von-Liebig-Weg 6
18059 Rostock
Phone: +49 (0)176 11004400
E-Mail: **fatih.goekgoez@dbfz.de**

Within just a few years, a large proportion of German existing biogas plants will meet their 20-year EEG payment period. Therefore, economic future concepts are required which at the same time contribute to the fulfilment of national climate targets. The focus of this paper is to examine different operating modes with regard to the integration of a decentralised off- grid biomethane filling station in an existing plant with combined provision of electricity and fuel. For this purpose, the necessary storage requirements as well as the costs for the different operating modes are determined and compared. Thereby the fully fuelled CHP operation proved to be the most cost-effective solution, even during seasonally fluctuating fuel consumption. This operation mode does not require any additional installation of biogas storage capacity. The avoided storage increase compared to the reference operation mode is 75%. The studies shows that a cost-effective integration of off-grid biomethane filling stations in existing biogas plants is possible.

References:
F. Gökgöz, J. Liebetrau, M. Nelles, Combining electricity and fuel supply - operational strategies for biogas plants, Chemical Engineering & Technology, Darmstadt 2020, submitted
F. Gökgöz, M. Winkler, T. Barchmann, S. Weinreich, J. Liebetrau, M. Nelles, Combined supply of electricity and fuel at biogas plants - future scenarios, economy, comparison, Landtechnik, Darmstadt 2020, accepted.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

COMBINING ELECTRICITY AND FUEL SUPPLY - OPERATIONAL STRATEGIES FOR BIOGAS PLANTS

Fatih Gökgöz[1], Jan Liebetrau[2], Michael Nelles[1,3]

1 ISSUES & OBJECTIVE

By fueling GHG-saving biofuels in vehicles, attractive income for biogas plants can be generated by marketing of the quota from GHG reduction against fossil fuels. But the operation of a off-grid biogas filling station poses a problem: while the biogas production is almost constant, the fuel consumption is discontinuous. This temporal discrepancy results in very large biogas storage capacity demand. This can be solved with a new operation variant: a combined fuel & power production at biogas plants with fuel-led CHP operation. The advantage over usual operation can be seen visually in figure 1. The total consumption of biogas (fuel+power) is constant every day.

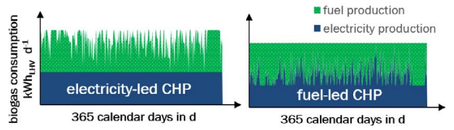


Figure 1: Exemplary biogas consumption in electricity-led (left) and fuel-led (right) CHP operation; the annual aggregated raw biogas consumption are the same for both cases

2 METHODS

For the evaluation, data on electricity prices on the european power exchange and refuelling data (see figure 2) of four fleet operators were analyzed. To determine the CHP hours with optimized electricity prices, the price ranking method is used. The prices are given a ranking from 1 (highest) to 24 (lowest) within each day. Now the daily available runtime of the CHP unit can be placed on the hours with the highest prices. In the electricity-led CHP operation, the daily available runtime is constant 12 hours.

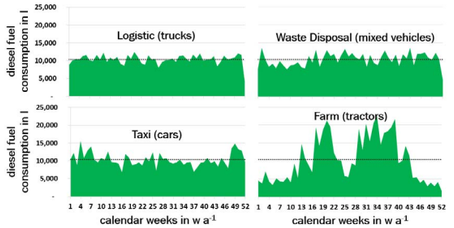


Figure 2: Weekly refuelling quantities of four fleet companies (dotted line: average value)

In the fuel-led CHP operation, the number of daily available hours varies depending on the biogas demand for fuel production (see figure 3, right axis).
The study was carried out for a typical agricultural biogas plant with 500 kW_{el} CHP output and an existing storage capacity of 5.618 m³. The average rated capacity of the biogas filling station is 60 m³/h (STP) biomethane. The biogas is used 50% each for electricity and fuel production.

3 RESULTS

Table 1 shows the additional biogas storage demand depending on the vehicle fleet type. In the case of usual operation, the capacity demand is too large, especially for the agricultural vehicle fleet. Against this, the fuel-led CHP operation leads to constant daily biogas consumption (see figure 3) and therefore no additional biogas storage capacity is needed. The average saving on additional biogas storage demand is 75%.

operation type	logistic	waste disposal	taxi	agricultural
electricity-led in m³ (usual operation)	19,015	16,780	15,318	38,125
fuel-led in m³	4,936	4,900	4,916	5,422
saving in %	74,0	70,8	67,9	85,8

Table 1: Demand for biogas storage for biogas plants with electricity and fuel production

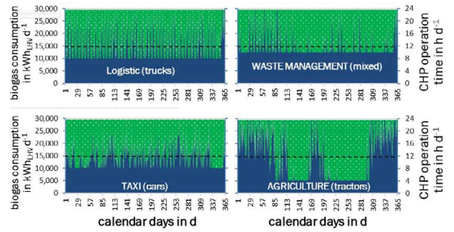


Figure 3: Biogas consumption for electricity and fuel production with fuel-led CHP operation

4 CONCLUSIONS

1. In the case of an off-grid biogas filling station, a discontinuous fuel demand leads with the usual CHP operation to an enormous biogas storage demand.
2. Fuel-led CHP operation enables a biogas filling station without additional biogas storage demand. Even with strongly fluctuating fuel consumption as in agriculture.

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartner: Fatih Gökgöz | E-Mail: fatih.goekgoez@dbfz.de | Telefon: +49 (0)176

[1] DBFZ, Biochemical Conversion, System Optimisation, Torgauer Str. 116, 04347 Leipzig
[2] Rytec, Pariser Ring 37, 76532 Baden-Baden
[3] University Rostock, Waste and Resource Management, Justus-von-Liebig-Weg 6, 18059 Rostock

18th September, 2020 | 10:00 - 11:00

Philipp Riechmann, Paul Scherer Institute

Using Global X-Ray Tomography Data to Evaluate Local Optical Probe Measurements

Philipp Riechmann
Paul Scherer Insitute
Forschungsstrasse 11
5232 Villigen PSI
E-Mail: philipp.riechmann@psi.ch

One of the biggest current challenges of humanity is the anthropogenic climate change, which will have drastic effects on the living conditions in a global scale, if we cannot reduce global warming significantly. The thermochemical conversion of biomass and subsequent methanation as a source of synthetic natural gas (SNG) could be one way to address this issue.

At the Paul Scherrer Institut a bubbling fluidized bed methanation reactor with vertical heat exchanger tubes is in development. Understanding the bubble characteristics is very important because they influence the heat and mass transfer crucially. A pilot plant, referred to as GanyMeth, is currently under commissioning and operational at pressures of up to 11bara with pressurized air at ambient temperatures. The plant includes optical probes that can measure local chord lengths and rise velocities of bubbles at different heights and radial positions. One major drawback of such sensors is that only chord lengths are measured and statistical methods are necessary to estimate the bubble size and velocity distribution, which requires further knowledge of the shape distribution of the bubbles. For a better understanding of such bubble characteristics and their distributions, X-Ray tomography measurements of a bubbling fluidized bed in a Perspex model of the reactor were carried out in cooperation with the Delft Technical University.

Key findings:

1. There seems to be a correlation between the aspect ratio (vertical length/horizontal width) of a bubble and its rising velocity.
2. The chord length distributions of bubbles indicate a significant deviation from spherical bubble shapes.

3. It appears viable to apply these findings to measurements with optical probes, allowing good estimations of bubble shape, volume and rise velocity distributions. This would be especially useful to estimate a possible breakthrough of reactants in a fluidized bed reactor.

biosweet
Biomass for Swiss Energy Future
Swiss Competence Center for Energy Research

Supported by:
Schweizerische Eidgenossenschaft
Confédération suisse
Confederazione Svizzera
Confederaziun svizra
Swiss Confederation
Innosuisse – Swiss Innovation Agency

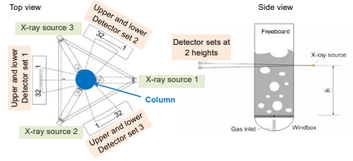
Using Global X-Ray Tomography Data to Evaluate Local Optical Probe Measurements

P.Riechmann[1], T.J.Schildhauer[1*], F.Schillinger[1], E.C. Wagner[2], R F. Mudde[2], J.R.van Ommen[2]
[1] Paul Scherrer Institut (PSI), CH-5232 Villigen PSI, Switzerland, [2] Delft University of Technology, Van der Maasweg 9, 2629 HZ Delft , The Netherlands

Key findings
X-ray tomography has been applied to measure single bubble properties in a cold flow model of a bubbling fluidized bed reactor. The evaluation of the data lead to the following findings:
1. There seems to be a correlation between the aspect ratio (vertical length/horizontal width) of a bubble and its rising velocity.
2. The chord length distributions of bubbles indicate a significant deviation from spherical bubble shapes.
3. It appears viable to apply these findings to measurements with optical probes, allowing good estimations of bubble shape, volume and rise velocity distributions. This would be especially useful to estimate a possible breakthrough of reactants in a fluidized bed reactor.

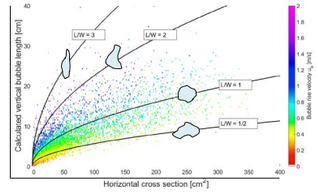
X-ray tomography of bubbling fluidized beds

By using three X-ray sources with two associated detector sets at two heights each, it is possible to reconstruct three-dimensional images of each bubble within the determined thresholds. In this way, the entire geometry of each bubble as well as its dynamics within the two measurement planes are accessible. The measurements were obtained in a cold flow reactor model (d_{column} = 22cm) with alumina particles (Geldart B) and air as a fluidization medium at different heights and different flow rates with a resolution of 55x55 pixels and a framerate of 2500Hz. In total of 29559 bubbles have been evaluated.



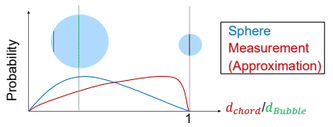
Correlation between the rise velocity and the aspect ratio of bubbles

For each evaluated bubble, the aspect ratio of vertical length to horizontal width as well as the rise velocity was determined. The results show a clear correlation between the two mentioned parameters. This information can be used to develop a distributional correlation which would allow an estimation of the bubble shape and thus of the bubble volume when the vertical length and the rise velocity of the bubble are known.



Chord length distributions

The entire set of chord lengths of every measured bubble was registered and associated with the corresponding vertical bubble length and aspect ratio of that bubble. Therefore the probability distribution of piercing a bubble of a defined shape and size with a certain chord length can be determined. A clear aberration of what would be expected of spherical bubbles was observed.



Bubble hit probability

Since it was discovered that bubbles of different aspect ratios but same volumes would on average rise with different velocities, there is a bias when measuring with optical probes, because bubbles with large horizontal cross sections are over-represented due to their higher likelihood of being pierced by an optical probe. This has to be accounted for when evaluating optical measurements with the methods introduced in this scope.

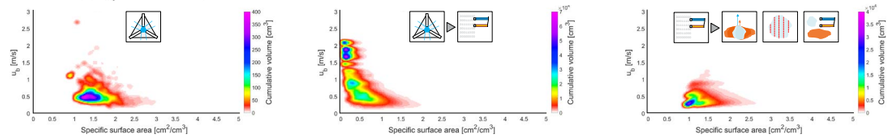
Reconstructed signal of an ideal optical sensor from X-ray tomography data

An artificial optical signal was reconstructed from the X-ray tomography data. From both the X-ray measurements, as well as the reconstructed optical measurements, the volumetric distribution of the specific surface area and the bubble rise velocity were determined. It could be shown that the application of the above mentioned statistical methods lead to a significant improvement of the optical measurements evaluation.

Data derived via X-ray tomography
$(u/u_{mf} = 2, H = 46cm)$

Reconstructed optical data with assumption of spherical bubbles and no statistical effects considered

Reconstructed optical data after application of derived statistical methods



PAUL SCHERRER INSTITUT
PSI

*Corresponding Author: tilman.schildhauer@psi.ch | www.sccer-biosweet.ch | 9/9/2020

POSTER PRESENTATIONS

SESSION 4
THERMOCHEMICAL CONVERSION

3RD DOCTORAL COLLOQUIUM BIOENERGY

18th September, 2020 | 10:00 - 11:00

Thomas Schliermann, Deutsches Biomasseforschungszentrum

Recycling of ashes from thermo-chemical conversion of agricultural residues

Thomas Schliermann
Deutsches Biomasseforschungszentrum
Torgauer Str. 116
04347 Leipzig
Phone: +49 (0)341 2434-463
E-Mail: **thomas.schliermann@dbfz.de**

The appropriate use of agricultural residues often poses a challenge that has not yet been completely resolved due to the large quantities involved. For residues such as straw or husks, there is still a need for innovative solutions to utilize the enormous amounts. Optimized routes are being sought, especially also in Asian countries, since burning straw in the fields is no longer permitted. One way can be the optimized thermo-chemical conversion of such residues. However, due to the high ash content of these biomasses, there are special requirements for process control. In the ideal case in addition to avoiding problems in operation due to e.g. slagging, a second product - namely the ashes - can be obtained from the residual material in addition to heat. This is possible for e.g. rice husks or rice straw with a high ash content of up to approx. 20% by mass. This ash consists largely of silicon dioxide. Through optimized process control e.g. in direct combustion it can be achieved that the ash obtained is X-ray amorphous and has a porous internal structure. Such silica ash - so-called biogenic silica - is a sought-after resource. The combustion ashes can contain different proportions of remaining carbon depending on the process conditions: An interesting field of application for such ashes is the use as a catalyst support material. For this purpose, upgrading the ashes with regard to the pore system and the form factor is advantageous e.g. producing granules out of the powdereous ashes. The aim of the article is to show results on the production process and its optimization and report obtained properties of the resulting ash granules.

18th September, 2020 | 10:00 - 11:00

Andrea Dernbecher, Deutsches Biomasseforschungszentrum

Experimental and numerical investigation of a log wood stove

Andrea Dernbecher
TU Berlin
Torgauer Str. 116
04347 Leipzig
Phone: +49 (0)341 2434-417
Mail: **andrea.dernbecher@dbfz.de**

The further expansion of bioenergy in the field of domestic heating requires the use of innovative technologies. New challenges for biomass furnaces arise from changes in the legal framework, the desire for plants with high efficiency and also from a growing awareness among customers for environmentally friendly and low-emission furnaces. Computational Fluid Dynamics (CFD) is a valuable tool to address these challenges and to advance the development of innovative combustion technology. However, CFD is not yet used to its full extend for the improvement of domestic biomass combustion systems, because various sub-models and sufficient computational resources are required. In this study, a logwood stove was investigated by means of combustion tests and CFD simulations. The aim of the study was the validation of the simulation method used. In addition, the CFD results were used to gain a better insight into the processes within the combustion chamber and to show potential for improvement. The model created will subsequently be used to investigate the influence of changes in geometry or additional internals on the flow within the furnace. For the investigation of the combustion by CFD the combustion chamber was transformed into a three-dimensional model. Simulations were performed with the OpenSource software OpenFoam. Start and boundary conditions were determined from the measurement results. The necessary models for the representation of the biomass bed, turbulence, mixing of fuel and air, combustion reactions and radiation were adapted to the furnace under investigation. Especially the influence of the turbulence model on the accuracy of the simulation results was analyzed. The results of the simulation and the measurements were compared with each other regarding temperature distribution, gas composition and flame pattern. A good agreement of the simulated and experimentally determined values was achieved.

WINNER BEST POSTER AWARD

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Experimental and numerical investigation of a log wood stove
Andrea Dernbecher

Introduction

Domestic combustion plants for the combustion of biomass cause a large part of the emissions in Germany, especially dust and carbon monoxide emitted. Modern and innovative combustion plants are necessary to reduce the emission of pollutants. The construction and design of low-emission wood log stoves can be supported by numerical analysis with computational fluid dynamics (CFD).

Figure 1: Furnace investigated in this study

Simulation

Simulations were performed in OpenFOAM with start and boundary conditions determined in experiments. The combustion was simulated with an empirical bed model, in which the surface of the logs is used as an inlet for combustible gases. Eddy dissipation concept (EDC) was used as combustion model and a reduced GRI-mech 3.0 as reaction mechanism.

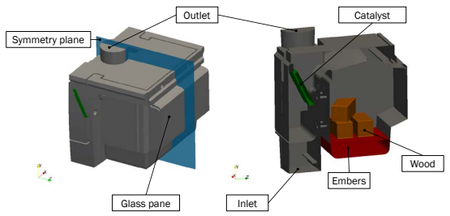


Figure 2: Geometry of the Furnace with wood logs and catalyst

Results

A complex flow is created in the stove which leads to a good mixing of air and fuel gases. Low oxygen content and high temperature were observed in the region of the flame.

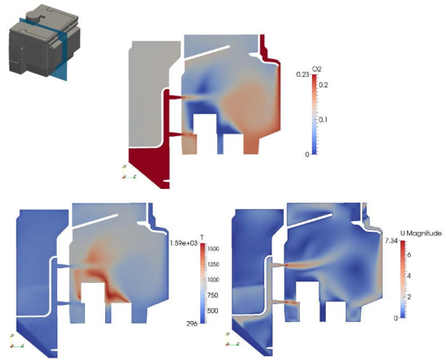


Figure 3: Simulated distribution of oxygen (mass fraction), Temperature (K) and velocity (m/s) in the combustion chamber

Temperature was measured in various positions in the combustion chamber. Fig. 4 shows the mean values of the measurement during the stationary phase in comparison the simulation results. Error bars indicate the standard deviation.

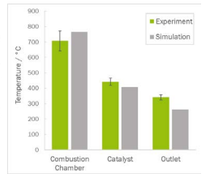


Figure 4: Comparison of measured temperature during the stationary phase and simulated temperature

Conclusions and Outlook

The selected models were well suited to represent the combustion in the small combustion plant under investigation. Further simulations to investigate the influence of catalysts are necessary.

gefördert durch DBU Deutsche Bundesstiftung Umwelt

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartner*innen: Andrea Dernbecher | E-Mail: andrea.dernbecher@dbfz.de | Telefon: +49 (0)341 2434-417

18th September, 2020 | 10:00 - 11:00

Mario König, Deutsches Biomasseforschungszentrum

Development and application of novel SCR catalysts for the lowtemperature denitrification of exhaust gases from the thermo-chemical conversion of biogenic solid fuels

Mario König
Martin-Luther-University Halle-Wittenberg
Universitätsplatz 10
06108 Halle
Phone: +49 (0)341 2434-569
E-Mail: **mario.koenig@dbfz.de**

Nitrogen oxides are one of the most problematic group of pollutants in the thermal conversion of biomass. As precursors, they are responsible for the formation of photochemical smog, acid rain and ground-level ozone as well as for the destruction of the ozone layer and, in the form of N2O, also for global warming. In the future non- woody biomasses with increased nitrogen contents has to be used for energy generation. In order to comply with legal emission limits, suitable NOx reduction processes must be available. Existing reduction measures for nitrogen oxides do not have the technical and economic potential to be used in decentralised bioenergy plants because they only work at higher temperature ranges and they can only be applied in the power plant sector. For the effective abatement of nitrogen oxides from biomass furnaces, suitable catalysts for the low- temperature range must be developed. Within the experimental work for the dissertation, corresponding catalysts for the selective catalytic reduction of NOx on basis of metal oxides are investigated. Based on a literature survey catalyst materials are selected which are suitable for feeding into the exhaust gas in particulate form and which can also be produced, used and disposed of in an economical and environmentally friendly manner. The investigations are initially focused on MnOx- and SiO2-based catalysts as they show a promising activity and at the same time they seem to be economical and environmentally friendly in comparison to conventional SCR catalysts. Currently, suitable catalytic materials and mixtures are being sought through laboratory- scale tests on an in-house developed reactor by determining the activity of synthesized powders. A small amount of the catalyst powder is introduced into the reactor and a synthetic gas mixture flows through it. By varying the reactor temperature and measuring the gas composition downstream of the reactor, temperature conversion curves can be determined and, in addition, information on selectivity can be obtained by measuring the ammonia slip Promising catalyst mixtures found after the catalyst screening are characterized using standardized methods: H2-TPR, XRD, determination of the BET surface, mercury porosimetry. (< 250 °C) After catalyst characterization selected catalysts will be investigated on a pilot scale. The influence of operating conditions (temperature, space velocity, SO2 and H2O content in the exhaust gas), the long-term stability and possible deactivation by SO2 and H2O will be investigated and conclusions for an optimization of the catalyst composition will be made.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

DEVELOPMENT AND APPLICATION OF NOVEL SCR CATALYSTS FOR THE LOW-TEMPERATURE DENITRIFICATION OF EXHAUST GASES FROM THE THERMO-CHEMICAL CONVERSION OF BIOGENIC SOLID FUELS

Mario König

MOTIVATION

Nitrogen oxides (NO_x) are one of the most problematic group of pollutants in the thermal conversion of biomass. They are responsible for many health-related and environmental problems. In the future non-woody biomasses with increased nitrogen contents has to be used for energy generation. In order to comply with legal emission limits, suitable NO_x reduction processes must be available. Existing measures do not have the technical and economic potential to be used in decentralized bioenergy plants. For the effective abatement of NO_x from biomass furnaces, suitable catalysts for the low-temperature range must be developed.

SCIENTIFIC ISSUES

- Investigation of suitable materials and synthesis routes for low-temperature catalysts considering technical, economic and environmental issues
- Catalyst characterization using standard methods like H_2-TPR, XRD, BET surface, Hg-porosimetry
- Determination of activity on laboratory scale
- Influence of operating conditions (exhaust gas temperature, space velocity, SO_2 and H_2O)
- Determination of the attainable NO_x reduction with selected catalyst powder in combination with a fabric filter on a pilot scale multifuel-boiler

RESULTS LITERATURE REVIEW

In the last two decades a considerable number of publications on the subject of low-temperature NH_3-SCR were published. Based on an extensive literature research the following statements can be made:

- Mn-based catalysts are the most promising for low-temperature NH_3-SCR on solid fuel combustion
- Mixing/doping with other metal-oxides (e.g. Fe, Ce, Co, Cu) increases activity and H_2O/SO_2-resistance
- Application of Manganese-oxides on catalyst carriers (e.g. TiO_2, Al_2O_3, AC, ZSM5, SAPO, SiO_2, CeO_2) influences activity and H_2O/SO_2-resistance
- In low-temperature NH_3-SCR both – the ER- and the LH-reaction mechanism – occur in parallel
- to date, the greatest challenge in the low temperature range is SO_2 and H_2O resistance

By influencing the listed properties, an increase in the NOx-conversion rate and the resistance of the SCR catalyst can be achieved.		Elements for doping of Mn-based SCR-Catalysts												
		Ce	Co	Fe	Cu	Zr	Cr	Mo	Ca	La	Ni	W	Y	Li
Impact on catalyst properties	Absorption of more NO_3^-	x	x											
	Higher surface acidity	x	x	x										
	Higher surface area	x												
	Provision of surface-adsorbed O_2	x		x									x	x
	Good dispersion of MnO_x on the surface	x		x		x	x	x	x	x				
	Affects oxidation state of manganese	x						x			x	x		
	Decrease of reduction temperature of MnO_x				x									
	Decrease of water adsorption			x										
	Increase of SO_2-resistance	x	x	x			x					x	x	

Figure 1: Effects of doping Mn-based catalysts with different elements
sources: F. Gao et al. Ch. Eng. J. 317 (2017), T. Lee et al. AIMS Env.Sci. 3 (2016), C. Liu et al. Appl.Cat.A: Gen. 522 (2016), L. Qiu et al. Appl.Surf.Sci. 357 (2015), L. Liu et al. Aer.AirQual.Res. 14 (2014), G. Yang et al. Appl.Cat.B: Env. 245 (2019)

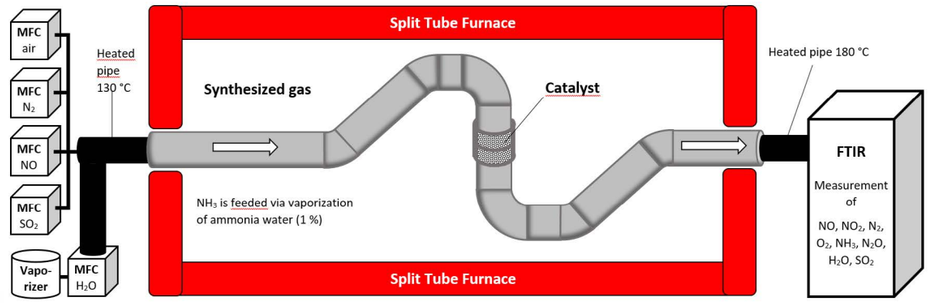


Figure 2: Laboratory-scale-reactor for catalyst screening (stainless steel tube with 10 mm inner diameter)

MARTIN-LUTHER-UNIVERSITÄT HALLE-WITTENBERG

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartner: Mario König | E-Mail: mario.koenig@dbfz.de | Telefon: +49 (0)341 2434-569 | Fax: +49 (0)341 2434-133

18th September, 2020 | 10:00 - 11:00

Hossein Beidaghy Dizaji, Deutsches Biomasseforschungszentrum

Ash-melting tendency of rice husk during combustion

Hossein Beidaghy Dizaji, Thomas Zeng, Prof. Dirk Enke, Prof. Gert Kloess, Hieronymus Hölzig
Leipzig University
Grimmaische Str. 12
04109 Leipzig
Phone: +49 (0)176 28516427
E-Mail: **hossein.beidaghy@dbfz.de**

Commonly, porous silica is produced on industrial scale by precipitation from alkaline silicates. This process is very energy intensive and expensive, and it produces a lot of waste water as a pollution. Therefore, an economic feasible and environmental benign route as an alternative method is required to produce silica. A combined energy generation and biogenic silica production from Si-rich rice husk (RH) under controlled conversion conditions would be a promising approach. Rice husk ash (RHA) has a high share of silica content, which is typically called biogenic silica. Besides silica content, main ash-forming elements in RH are Si, Ca, Mg, K, Na, P, S, Cl, Al, Fe, and Mn [1]. Association of these ash-forming elements along with higher ash content can cause ash related problems [2]. Our preliminary investigation showed that silica-rich biomass assortments have high ash-melting tendency compared to wood [3]. However, ash-melting tendency of RH during combustion have not been fully understood in literature. Thus, in the present study, a detailed investigation has been conducted using different spectroscopy techniques to address ash-melting tendency in RH. Results of this study provide a detailed understanding of slag-formation in silica-rich biomass assortments providing a general guideline for industrial users to produce biogenic silica from combustion of RH.

References
1. Beidaghy Dizaji, H.; Zeng, T.; Hartmann, I.; Enke, D.; Schliermann, T.; Lenz, V.; Bidabadi, M. Generation of High Quality Biogenic Silica by Combustion of Rice Husk and Rice Straw Combined with Pre- and Post-Treatment Strategies—A Review. Applied Sciences 2019, 9, 1083, doi:10.3390/app9061083.
2. Boström, D.; Skoglund, N.; Grimm, A.; Boman, C.; Öhman, M.; Broström, M.; Backman, R. Ash Transformation Chemistry during Combustion of Biomass. Energy Fuels 2011, 26, 85–93, doi:10.1021/ef201205b.
3. Beidaghy Dizaji, Hossein; Zeng, Thomas; Enke, Dirk, Evaluation of ash melting behavior of rice husk and rice straw during thermochemical conversion, 6th Central European Biomass Conference (CEBC 2020), Graz, Austria, 22-24 January 2020.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

ASH-MELTING TENDENCY OF RICE HUSK DURING COMBUSTION

Hossein Beidaghy Dizaji*[1,2], Amirhossein Zareihassangheshlaghi [1-3], Thomas Zeng [1], Paula Huth [3], Thomas Ruf [3], Reinhard Denecke [3] and Dirk Enke [2]

BACKGROUND AND AIM OF INVESTIGATION

In the near future, biomass combustion will play an important role in the reduction of greenhouse gas emissions. Thus, unique opportunities to combine energy generation with the valorization of remaining ashes is of great importance. Consequently, innovative and integrated approaches producing biogenic silica based on the remaining ashes from the combustion of SiO_2-rich biomass such as rice husk can contribute to this development. However, risk of ash melting during combustion of silica-rich biomass is one of the main barriers.

RESEARCH QUESTIONS

- Q1. Is it possible to mitigate initiation of biomass ash melting especially on microscopic -scale?
- Q2. How we can produce 100 wt.% pure and amorphous biogenic silica?

MATERIALS AND METHODS

Rice husk (RH), water-washed rice husk (WRH) and citric-acid leached rice husk (LRH) were combusted and analyzed as shown in Fig. 1.

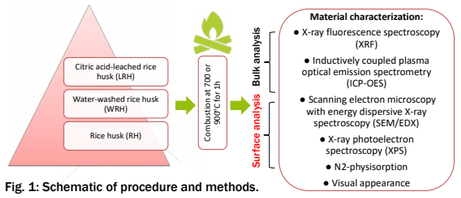


Fig. 1: Schematic of procedure and methods.

RESULTS AND DISCUSSION

Surfaces of the ash particles are characterized by a distinct different level of metal impurities as compared to the bulk (Fig. 2 and Fig. 3). Ball milling (BM) of untreated rice husk ashes supports the presence of a higher concentration of impurities on the surface rather than in the bulk of the ash particles (Fig. 2). Fuel pre-treatment decreases level of problematic elements (i.e. K and Na) with regard to the ash melting tendency in both bulk and the surface of the ashes (Fig. 3). According to Fig. 4, ash slagging starts on microscopic level on the surface of the ash particles resulting in a reduced porosity (V_{ads}).

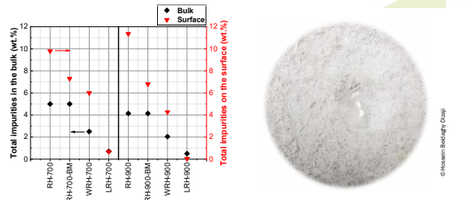


Fig 2.: Total level of impurity in the bulk (ICP-OES data) and surface (XPS data) of rice husk ashes (left), visual appearance of the final product LRH-900 (right).

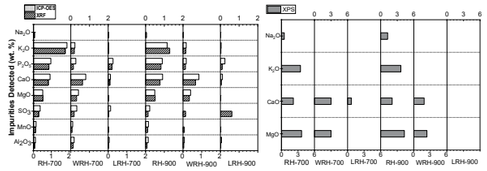


Fig 3.: Concentration of metal impurities in the bulk (left) and on the surface (right).

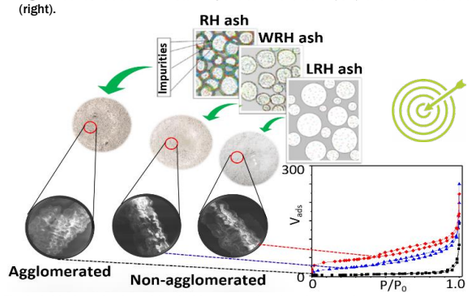


Fig 4.: Initiation of ash melting in biomass ashes in microscopic scale.

CONCLUSIONS

It was found that surfaces of biomass ash particles are characterized by different level of metal impurities compared to the bulk, which is the initial starting point for ash melting on microscopic level at elevated temperatures. Silica purity in the ash was enhanced to nearly 100 wt.% by fuel pre-treatment.

ONGOING RESEARCH

- Qualitative and quantitative chemical phase analysis of rice husk ashes.
- Prediction of initial ash melting on microscopic level during combustion of Si-rich biomass assortments.

[1] DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Leipzig, Germany
[2] Institute of Chemical Technology, Leipzig University, Leipzig, Germany
[3] Wilhelm-Ostwald Institute, Leipzig University, Leipzig, Germany
*Corresponding author: Hossein Beidaghy Dizaji, Torgauer Straße 116, 04347 Leipzig, www.dbfz.de, hossein.beidaghy@dbfz.de, Phone: +49 (0)341 2434-539

UNIVERSITÄT LEIPZIG
Bundesministerium für Ernährung und Landwirtschaft
Federal Ministry of Food and Agriculture

Scan QR codes to read more.

References: 1. Zareihassangheshlaghi et al., ACS Sustainable Chemistry & Engineering (2020), In Press.
2. Beidaghy Dizaji et al., Applied Science (2019) 9, 1083, doi:10.3390/app9061083.

Acknowledgments: This work was financed by funds of the German Federal Ministry of Food and Agriculture (BMEL) based on a decision of the Parliament of the Federal Republic of Germany via the Federal Office of Agriculture and Food (BLE).

18th September, 2020 | 10:00 - 11:00

Clement Owusu Prempeh, Deutsches Biomasseforschungszentrum

Thermochemical Conversion of Agricultural Residues for the Generation of Biogenic Silica for Mesoporous Silicon Carbide Synthesis

Clement Owusu Prempeh[1,2], Steffi Formann[1], Dr. Ingo Hartmann[1], Prof. Dr. Michael Nelles[1,2]
University Rostock
Justus-von-Liebig-Weg 6
18059 Rostock
Phone: +49 (0)176 35604168
E-Mail: **clement.owusuprempeh@dbfz.de**

[1] DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Str. 116, 04347 Leipzig

[2] University of Rostock
Justus-von-Liebig-Weg 6, 18059 Rostock

This study provides a comprehensive insight into the efficient use of silicon rich agricultural residues from selected African countries (South Africa and Ghana) for bioenergy and material applications. It focuses on the chemical pre-treatment of residues from food production and its combustion and gasification characteristics for combined heat and power production. The material use of the resulting amorphous, porous and reactive biogenic silica is considered for several advanced applications, e.g., silicon dioxide synthesis as a catalyst support for methane oxidation processes, adsorbent, and drug delivery systems, etc. The innovative study addresses aspects of climate change (i.e. climate neutral energy provision), efficiency and sustainability of agricultural production (i.e. use of residues, circular economy), soil degradation (i.e. biogenic fertilizer) and new transformation processes of agricultural production (i.e. new value chains). Accordingly, knowledge accrued on the energetic and material use of the agricultural residuals could be a springboard to new market opportunities for both German and African countries, and in effect create job opportunities.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Generation of Silicon Dioxide from Biomass for Industrial Applications

Clement Owusu Prempeh, Steffi Formann, Ingo Hartmann, Prof. Micheal Nelles

Introduction

The industrial production of mineral-based porous silica is energy-intensive, costly, and environmentally unfriendly. Si-containing plant-based biomasses are therefore viable feed for the production of silica due to their low cost and zero net emissions of Co_2. Hence, this work investigates the production of biogenic silica from silica-accumulating biomasses (Fig. 1), with the focus on accessible regional feedstocks from Africa that do not compete with the food industry.

Fig. 1. Images of proposed silicon rich-biomasses in this work

Methodology

We apply two main techniques for the generation of high quality high-grade porous biogenic silica: acidic pre-treatment of the biomasses followed by combustion. Consequently, the generated biogenic silica from the combustion is used for the subsequent synthesis of a catalyst support (Fig. 2).

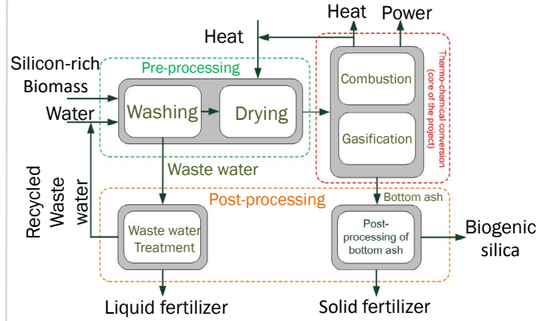


Fig. 2. Process scheme for value-added processing and conversion of agricultural residues

Aims & Objectives

To find a transformational use of agricultural wastes.

Outlook & Major contributions

This study contributes to:

- The understanding of biogenic silica synthesis.
- Advance characterization and improvement of the properties of high-grade biogenic silica.
- Knowledge on the energetic and material use of biogenic silica.

References

Pode, R. (2016) 'Potential applications of rice husk ash waste from rice husk biomass power plant', Renewable and Sustainable Energy Reviews. Elsevier Ltd, pp. 1468–1485. doi: 10.1016/j.rser.2015.09.051.
Biswas, B. et al. (2017) 'Pyrolysis of agricultural biomass residues: Comparative study of corn cob, wheat straw, rice straw and rice husk', Bioresource Technology. doi: 10.1016/j.biortech.2017.02.046.
Sunfleth et al. 2020" Poster presentation on Low iLUC risk indicators for sustainability and certification in EU Bioeconomy" in DBFZ file directory:https://sharepoint.leipzig.dbfz.de/websites/sharepoint/verwaltung/promotionsprogramm/PhD%20coffee/Forms/AllItems.aspx. Accessed on 30.08.2020.

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartner: Clement Owusu Prempeh
Clement.owusuprempeh@dbfz.de | Tel.: +49 (0)341 2434-523| Fax: +49 (0)341 2434-133

Annual DBFZ Conference, 2020

ORAL PRESENTATIONS

SESSION 3
BIOCHEMICAL CONVERSION

3RD DOCTORAL COLLOQUIUM BIOENERGY

18th September, 2020 | 11:05

Harald Wedwitschka, Deutsches Biomasseforschungszentrum

Method development for the characterization of feedstock materials for box type dry digestion processes

Harald Wedwitschka, Prof. Dr. Michael Nelles
University Rostock
Justus-von-Liebig-Weg 6, 18059 Rostock
Phone: +49 (0)341 2434-562
E-Mail: **harald.wedwitschka@dbfz.de**

Introduction
There is an increasing need for agricultural, industrial and municipal stakeholders for finding economical ways to solve waste treatment and disposal issues. The dry anaerobic batch digestion process is an appropriate treatment technology for stackable (non-free-flowing) relatively dry waste materials. According to information from garage fermentation plant operators, the garage process sometimes involves long start-up times and problems in post-composting due to a lack of material structure. Furthermore, process disturbances can occur, if the substrate material is not sufficiently water permeable. Within the scope of the dissertation project, the optimisation potential for the garage fermentation process by improvement of percolation is investigated on the example substrates dry chicken manure, solid manure from cattle fattening and biowaste. The overall aim of the PhD project is to increase the number of suitable substrates for the garage fermentation process and to enable an increase in the efficiency of the process by substrate conditioning and optimised process control.

Approach and methods
A substrate characterization method was developed with which feedstock material characteristics such as permeability and compressibility can be measured. Dry digestion experiments in lab and technical scale were carried out in order to determine if the conditioning of feed stock material characteristics can help to increase the substrate methane yield and process efficiency.

Results
Raw material characteristics such as permeability and compressibility were found to affect the process efficiency of dry batch anaerobic digestion processes.

Conclusion
The raw material conditioning of feedlot manure from cattle fattening, chicken manure and biowaste with structure building materials such as straw, woodchips or green cuttings can help to increase the substrate suitability for dry anaerobic batch digestion processes.

References:
Harald Wedwitschka, Earl Jenson, Jan Liebetrau: Feedstock Characterization and Suitability Assessment for Dry Anaerobic Batch Digestion. Chemical Engineering & Technology 01/2016; DOI:10.1002/ceat.201500413
Harald Wedwitschka, Daniela Gallegos, Michael Tietze, Jürgen Reinhold, Earl Jenson, Jan Liebetrau, Michael Nelles: Effect of substrate characteristics and process fluid percolation on dry anaerobic digestion processes. Chemical Engineering & Technology 10/2019;, DOI:10.1002/ceat.201900404
Harald Wedwitschka, Daniela Gallegos Ibanez, Walter Stinner, Michael Nelles: Material characterization and substrate suitability assessment of chicken manure for dry batch anaerobic digestion processes; to be submitted to Bioengineering in 06/2020
Harald Wedwitschka, Daniela Gallegos, Earl Jenson, Jan Liebetrau, Michael Nelles: Assessment of feedlot manure as substrate for biogas production with the dry batch anaerobic digestion process; to be submitted in 10/2020

18th September, 2020 | *11:30*

Markus Kolano, TU Berlin

Using Thrust to Control the Mixing Process in Biogas Fermenters

Markus Kolano, Matthias Kraume
TU Berlin
Straße des 17. Juni 135
10623 Berlin
E-Mail: **markus.kolano@tu-berlin.de**

In order to ensure a stable and efficient operation of biogas fermenters, the biosubstrates used therein must be sufficiently mixed. This is a challenging task because biosubstrates – due to their complex composition - exhibit non- Newtonian flow properties, which also may vary during operation depending on the feed, especially in flexibilized operation modes. The stirring technique used must therefore be continuously adapted to the changing conditions in the reactor.

Evaluating the efficiency of the mixing process is difficult, since used substrates are opaque and optical measurement techniques are not applicable. Indirect measures are therefore needed for an efficient and automated process control.

In this presentation, we evaluate whether thrust measurements can be used to determine the mixing efficiency of aforementioned systems. Using the particle image velocimetry method in combination with thrust measurements via strain gauges, mixing times determined by decolorization as well as CFD simulations, relationships between fluid dynamics, thrust and mixing times are derived for various single and multiple propeller mixing systems in pilot scale. For that, transparent model fluids with varying (viscoelastic) flow properties similar to bio substrates are used, allowing for the analysis of rheological dependencies.

It can be shown that independent of the used propeller geometries or the rheology of the fluids, mixing times t_M90 can be evaluated by using the measured thrust FA_x in the inertially dominated regime using the correlation $t_{M90} = 0.65 V_R \rho n d / FA_x$, with V_R being the vessel volume, ρ the density of the fluid, n the stirring rate and d the propeller diameter.

To ensure the correlations functionality also with real biosubstrates and at different reactor scales, it will be tested in full-scale at the research biogas plant Unterer Lindenhof in future works.

18th September, 2020 | 11:55

Johan Grope, University Rostock

Development of practical methods for parameter determination for model-based process monitoring on biogas plants

Johan Grope, Prof. Frank Scholwin, Sören Weinrich, Nils Engler
University Rostock
Justus-von-Liebig-Weg 6
18059 Rostock
Phone: +49 (0)172-5770415
E-Mail: **johan.grope@uni-rostock.de**

Introduction

i. In order to simulate the daily biogas production (target value) a model, based on a 1st order reaction model, is being used. The simulated daily biogas production is being compared with the actual measured biogas quantities (actual value). A major challenge in simulating the biogas process in a large-scale biogas plant is the quality of the available data. These are often inaccurate, incomplete or not high enough resolved. Therefore, the aim of this work is:
a) to identify and quantify the most relevant sources of error regarding the above- mentioned comparison of modelled and measured biogas values in a large-scale biogas plant
b) to estimate their influence on the accuracy of the result of the target-actual comparison of the biogas yield in a large-scale biogas plant
c) to find solutions for getting adequate results on the one hand and limiting the effort for data acquisition on the other hand.

ii. Approach and Methods

Based on technical data (e.g. measurement accuracies) and the experience during data acquisition at a large-scale biogas plant, which serves as the practical example for the project, the identified errors are quantified (maximum of deviation). A sensitive analysis based on the implemented biogas production model is performed in order to quantify the influence of each error on the daily simulated and measured biogas yield of the plant.

iii. Results

The analyse of inaccurate data has shown the following major sources of errors and the respective influence on the result of the daily accurate target-actual comparison of the biogas yield (additional average deviation between the simulated and measured daily biogas amount in %):
- daily fed substrate quantities (inaccuracy of the substrate scales): + 0.95%
- substrate specific content of organic dry matter (inhomogeneity of substrate an inaccuracy of laboratory tests): + 1.59 %
- gas storage levels (only four levels: 0 to 25 %, 25 to 50 %, 50 to 75 % and 75 to 100 %): + 13,42 %
- gas amounts (partly measured, partly calculated, e.g. from electricity production): + 1.95 %

By extending the accounting period from one to three days the average deviation between the simulated and the measured gas amount over a time span of six month could be reduced from 6.7 to 2.7 % with a standard deviation of 6 and 2 % respectively. The share of days with a deviation between the simulated and the measured gas amount of more than 5 % could be reduced from 52 to 14 %.

iv. Outlook

Further investigation will take place in order to test the tool with the data of more biogas plants in order to get a more complete picture about the challenges regarding data acquisition for model-based process monitoring on biogas plants. Furthermore, strategies will be analysed in order to find adequate methods for model parameter estimation, e.g. using simplex algorithms in MATLAB.

18th September, 2020 | 12:20

Daniela Gallegos Ibanez, Deutsches Biomasseforschungszentrum

Optimization of ensiling fermentation of Elodea genus for biogas production

Daniela Gallegos Ibanez, Prof. Dr. Walter Stinner
University Rostock
Justus-von-Liebig-Weg 6
18059 Rostock
E-Mail: **daniela.ibanez@dbfz.de**

Introduction

It is generally accepted today that, in order to efficiently meet world's rapidly growing energy demand, as well as to reduce greenhouse gas emissions (GHGs), increasing interest of the future energy supply should be focused on sustainable development of environmentally beneficial technologies. Despite anaerobic digestion process has been regarded as one of the more promising options for increasing biogas production, the use of energy crops, particularly corn, in agricultural biogas plants could make it a limited technology. Elodea is ubiquitous around the world in natural waterways its capacity to growth in freshwater results in high biomasses that do not compete with land-based food crops. To date, much of the research conducted on methane production has a smaller focus on the need for its preservation, which limits its potential use in commercial anaerobic digestion. The preservation of Elodea biomass is challenging as it contains relatively high water content and low concentrations of water-soluble carbohydrates. The objective of this study was to determine whether Elodea biomass could be successfully ensiled with addition of wheat straw as well as if the addition of additives affected silage quality and methane yields.

Approach and Methods

This study explores the potential use of aquatic biomass for generation of biogas. Silages preparation was carried out using Elodea with pretreated wheat straw. Elodea silages were prepared using pure Elodea. Silages were treated with three additives. Each silage was conducted in triplicates, resulting in 210 mini silos. The detailed method is described in Gallegos et al., 2017. Biomethane potential (BMP) tests were conducted at laboratory scale.

Results

pH values were between 4.4 and 6.5 and the volatile fatty acid content as lactic acid ranged from 0.0 to 7.1% TS. No butyric acid or only traces were found in mixed silages. Highest methane yields were achieved by mixed silages varying between 166 and 280 mL CH4 g-1 VS equivalent to 52% and 87% of corn silage. Combination of inoculant and enzymes only increased methane yield by 3% compared with the control silages. Considering the high methane potential (236 mL CH4 g-1 VS) and efforts for material pretreatment, the most promising silage was mixed silage at 2 cm of particle size at 30% TS.

Conclusions

Long storability of waterweeds can be achieved by ensiling fermentation. Mixed silages from Elodea and wheat straw can reach high biogas yields and show suitable material characteristics for agricultural biomass preservation in clamp silos.

References
1. Gallegos D, Wedwitschka H, Moeller L, Zehnsdorf A, Stinner W (2017) Effect of particle size reduction and ensiling fermentation on biogas formation and silage quality of wheat straw. Bioresour Technol 245:216–224. https://doi.org/10.1016/j.biortech.2017.08.137

ORAL PRESENTATIONS

SESSION 4
THERMOCHEMICAL CONVERSION

3RD DOCTORAL COLLOQUIUM BIOENERGY

18th September, 2020 | 11:05

Roman Adam, Deutsches Biomasseforschungszentrum

Clean combustion by combined adaption of wood pellet dimensions and design of a pellet stove with a capacity below 6kW

Roman Adam, Thomas Zeng, Dr. Volker Lenz
TU Bergakademie Freiberg
Akademiestraße 6
09599 Freiberg
Phone: +49 (0)341 2434-550
E-Mail: **roman.adam@dbfz.de**

Neuartige, automatisch beschickte Holzpelletfeuerungen sind in Bezug auf ihren Nutzerkomfort vergleichbar mit Heizöl- oder Erdgasheizungen. Besonders bei Pelletkaminöfen im kleinen Leistungsbereich unter 8 kW werden aufgrund der verbesserten Wärmedämmung im Gebäudebereich im zunehmenden Maße zum Einsatz kommen. Einige dieser Anlagen erreichen bei Teillast einen unteren einstelligen Leistungsbereich (< 3 kW) und benötigen nur wenige hundert Gramm Brennstoff pro Stunde. Bei dieser geringen Brennstoffzufuhr mit langen Intervallen zwischen den Brennstoffeinschüben ist aufgrund eines chargenähnlichen Abbrandes ein erhöhter Ausstoß an Kohlenstoffmonoxid- und Staubemissionen sowie organischen gasförmigen Verbindungen und klimaschädlichem Black Carbon zu erwarten. Abhilfe kann eine gezielte Reduktion der Pelletabmessungen (d.h. Länge und Durchmesser) sowie eine darauf abgestimmte Kleinstfeuerungsanlage schaffen. Die verringerte Brennstoffabmessung führt zum einen zur besseren Dosierbarkeit der Pellets und zum anderen zu einer homogenen Brennstoffschüttung mit gleichmäßig ebener Oberfläche des Glutbettes. Eine homogene Brennstoffschüttung im Bereich des Glutbettes sorgt weiterführend für eine homogene Durchströmung des Brennstoffbettes und verhindert auf diese Weise die Bildung von „heißen“ und „kalten“ Glutbettzonen, die die Entstehung von Schadstoffen begünstigen. Herkömmliche Kleinstfeuerungsanlagen sind für die Verbrennung von 6 mm Pellets konzipiert und sind bei einer Anpassung des Brennstoffes ebenfalls zu modifizieren, da andernfalls die positiven Effekte der Brennstoffreduktion überlagert werden. Unter der Zuhilfenahme des Simulationstools LIGGGHTS® werden die Pelletabmessungen ermittelt, die eine eben ausgebildete Glutbettoberfläche begünstigen. Darüber hinaus wird die Software OpenFOAM® verwendet, um die erforderlichen Anpassungen des Feuerungsraumes an den kleinformatigen Brennstoff zu berechnet. Parallel zu diesen Arbeiten wird die wirtschaftliche Herstellung der Pellets mit verringerten Abmessungen untersucht. Es werden erste Simulationen mit dem Programm OpenFOAM® zur Anpassung des Feuerungsraumes an den kleinformatigen Brennstoff vorgestellt. Zudem veranschaulichten Ergebnisse aus Voruntersuchungen zur Pelletherstellung den erforderlichen spezifischen Energiebedarf bei der Pelletierung. Verglichen wurde der Energiebedarf der Herstellung von Pellets mit verringerten Abmessungen mit der herkömmlichen Holzpelletproduktion im Technikumsmaßstab.

18th September, 2020 | 11:30

Benjamin Nun, Friedrich-Alexander-University Erlangen-Nürnberg

Agglomeration tendency of synthetic biogenic ashes in fluidised bed gasification

Benjamin Nun, Thomas Plankenbühler, Jürgen Karl
Friedrich-Alexander-University Erlangen-Nürnberg
Fürther Str. 244 f
90429 Nürnberg
Phone: +49 (0)911 53029059
E-Mail: **benjamin.nun@fau.de**

Fluidised bed systems are established plant types for the combustion and gasification of solid feedstock. However, high process temperatures (700 – 800 °C) still cause ash particles to melt even during operation of commercial plants; as a result, the bed material „sticks together“ and forms agglomerates. These agglomerates significantly change the fluidisation behaviour and can even lead to complete defluidisation of the fluidised bed.

On the one hand, this results in the necessity of a reliable detection of critical operating conditions of the fluidised bed system, on the other hand, it also raises the question of possibilities for active measures against agglomeration, for example by means of additives.

Therefore, at the Chair of Energy Process Engineering (EVT) of the University of Erlangen-Nuremberg experiments are carried out in a 5 kWth fluidised bed reactor. Changes in pressure loss and statistical evaluation methods such as the averaged pressure variance can detect reliably agglomeration processes. The ash particles used in the laboratory are synthetic mixtures of mineral oxides. The experiments investigated not only the effects of numerous operating parameters such as gas velocity or particle size distribution of bed materials and additives. They investigated in particular the influence of residual char on the tendency to agglomerate. Scanning electron microscope (SEM) images, supported by EDS measurements, provide information about the composition of the agglomerates and obvious formation mechanisms.

This conference contribution will present our methodology for agglomeration detection, the test rig and selected results from experiments with synthetic biomass ashes. In combination with SEM/EDS analysis, we validate and update our hypothesis regarding underlying agglomeration mechanisms for gasification conditions. Furthermore, the Department Chemie- und Bioingenieurwesen (CBI) presentation discusses the influence of fine char particles as a possible countermeasure to agglomeration in fluidised beds.

18th September, 2020 | 11:55

Markus Lang, RWTH Aachen University

Comparison of different methods to determine volatile matter and carbon content of biochars

Markus Lang, Peter Quicker, Kathrin Weber
RWTH Aachen University
Wüllnerstraße 2
52062 Aachen
E-Mail: **lang@teer.rwth-aachen.de**

Proximate analysis can be used as a fast determination method for the material composition of biochar. As with other analytical methods, there is no universally accepted standard for biochar. In contrast to elemental analysis there is less known about the comparability of different standards for proximate analysis of biochars. Most times the standards for solid biofuels or fossil coal are used for analysis. Even the European Biochar Certificate recommend these standards for biochar analysis

[1]. Aller et al. found that the lowest temperature to determine the volatile matter content for biochar should be 800 °C
[2]. Above this temperature, the mass loss rate is significantly lower than at temperatures below 800 °C. Nevertheless, even at higher temperatures a difference in the mass loss rate is still visible, for example by comparing the determination method at 900 and 950 °C for the volatile matter according to the European and American standard, respectively
[3]. The aim of the presented work is to compare the determination methods for proximate analysis, especially volatile matter content, with different devices under similar conditions. In a first step, all relevant standards are compared. Analysis of all feedstocks are done with the standards for both solid biofuels and for fossil coal. A wide range of different substances from fossil coal to the biomass structural components as well as different biomasses and their associated biochars are used for this investigation. The volatile matter content of the feedstocks was determined on the one hand by muffle furnace and on the other hand by using a thermogravimetric analyzer (TGA). To better compare the results of both devices the parameters of muffle furnace experiments are also used for the analysis with TGA. In addition to the equipment comparison, investigations were also carried out with regard to other sample quantities and modified analysis procedures, such as longer residence times. The results shall help to standardize the proximate analysis of biochars and to improve the comparability of different analysis. First results show a big difference depending on the analysed material and the used method when comparing the determination of the volatile components and the calculated amount of fixed carbon. The heating phase could play a decisive role, since the volatile content is determined according to the standard method in the preheated oven, whereas the sample in the TGA is slowly heated up. This seems to have different effects on materials with either still high volatile content or on already pre-degassed biochar, which makes it difficult to compare raw material and pyrolysis product.

[1] European Biochar Certificate
[2] Aller, D. et al.: Modified method for proximate analysis of biochars, 2017
[3] Enders, A. and Lehmann, J.: Proximate analyses for characterising biochars, 2017

18th September, 2020 | 12:20

René Bindig, Martin-Luther-University Halle-Wittenberg

Procedure for the development of catalysts for the reduction of emissions from small-scale combustion plants

René Bindig
Deutsches Biomasseforschungszentrum
Torgauer Str. 116
04347 Leipzig
Phone: +49 (0)341 2434-746
E-Mail: **rene.bindig@dbfz.de**

Catalysts are an important basis for almost all industrial processes as well as for exhaust aftertreatment. Process optimizations and adaptations to changed boundary conditions make the new and further development of catalysts necessary. Catalyst development is therefore a topic of constant high relevance. Great difficulties and uncertainties in catalyst development arise particulary during the final step, i.e. scale-up to real scale. A reliable estimation of the behaviour of a newly developed catalyst in real applications based on laboratory results would minimize the risk of having to repeat the final, cost-intensive development step several times. This could significantly reduce the overall development costs. Furthermore, on a laboratory scale and under otherwise identical conditions a more exact recording of the temperature or temperature distribution over the catalyst is possible. This is associated with a more precise estimation of the causes of ageing. This is because temperature peaks, which have a decisive influence on the ageing of catalysts, can be excluded or detected. The aim of the thesis is the development of a multi-stage procedure with which the behaviour of a full-scale, newly developed catalyst can be reliably estimated. For this purpose, experimental data are generated in suitable test rigs, using samples on a laboratory scale. These data are to be incorporated into a mathematical model. This model will be used to describe the conversion-temperature behaviour of the full-scale catalyst under the conditions in a real combustion plant. The scope of application is restricted initially to the development of catalyts for exhaust aftertreatment of combustion plants in the small capacity range (i.e. combined heat and power plants and small-scale combustion units). The test rigs, which are necessary for the procedure, were designed and set up. With the help of a commercially available catalyst, the suitability of the test rigs for this procedure is to be proven and the mathematical model to be derived. The test rigs and the data obtained from them are presented and discussed, and concepts for model development are presented.

POSTER PRESENTATIONS

SESSION 5
BIOREFINERIES

3RD DOCTORAL COLLOQUIUM BIOENERGY

18th September, 2020 | 13:30 - 14:45

Musa Bishir, University of Hohenheim

Comparative Performance of Two Different Locally Made Corncob Electrodes and Graphite for Electricity Generation in Microbial Fuel Cells (MFCs)

Musa Bishir, M Tariq, D. Wüst, Andrea Kruse
University of Hohenheim
Garbenstr. 9
70599 Stuttgart
Phone: + 49 (0)152 19301670
E-Mail: **musa.bishir@uni-hohenheim.de**

Microbial fuel cell (MFC) is an evolving technology for the anaerobic bioenergy generation using electrodes and organic wastewater as a feedstock for electrogenic bacterial catabolic activities and electricity generation. The search for suitable inexpensive electrode materials remain the leading interest of researchers in this field. The work here deals with biobased carbon materials for the electrodes. In view of the production of biobased carbon materials, hydrothermal carbonisation (HTC) is an interesting first step, this increases the carbon content relative to biomass. Unfortunately, HTC produces process water rich in organic compounds. Therefore, the possibility of bioelectricity generation from process water (pH = 5.99) of HTC and ammonium molybdate treated–biogas digestate (pH = 7.97) was evaluated in a dual-chambered microbial fuel cell (MFC). The electrodes tested separately for the three MFC set up were graphite rod (Theoretically zero surface area), KOH–activated corncob char (5:1) of BET surface area, 1626m^2/g and steam activated corncob biochar (485.8m^2/g). The maximum power outputs achieved were 323.8µW and 316.8µW from HTC process water with steam activated and KOH activated char electrodes, respectively and at 47Ω external load. The MFC operated with KOH–activated corncob char electrode performed efficiently with Coulombic efficiency of 75% in a comparatively shorter residence time of MFC operation than steam activated char electrode with lower Coulombic efficiency of 64%.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Comparative Performance of Two Different Locally Made Corncob Electrodes and Graphite for Electricity Generation in Microbial Fuel Cells (MFCs)

Musa Bishir[1] | Marium Tariq[1] | Dominik Wüst[1] | Lena Schleicher[2] | Julia Steuber[2] | Andrea Kruse[1]

INTRODUCTION

The World's energy demand is rapidly increasing and 80% of this requirement is fulfilled by the fossil fuels to meet the current energy needs. It is expected that by the year 2050, the world's energy demand will multiply by a factor of two (2) compared to today's energy usage level.

Moreover, an increased use of fossil fuels not only poses a problem of finite resources depletion but it also causes detrimental environmental impacts effects of which are already evident worldwide via increasing levels of pollution and climate changes.

Therefore, leading efforts are devoted to producing bioenergy using alternative methods from renewable resources such as microbial fuel cells (MFC) which significantly reduce carbon emissions to the environment.

METHODOLOGY

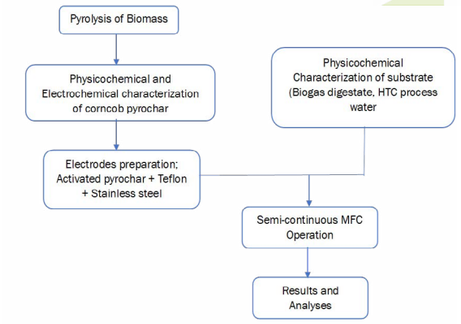


FIGURE 1 Flow-Chart of the Methodology

RESULTS

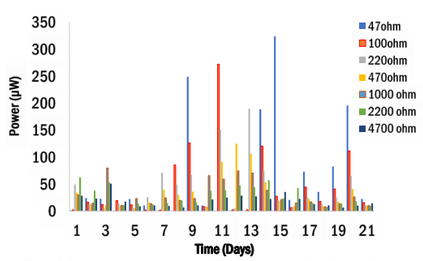


Figure 2: Power versus time plot of the MFC with steam activated corncob pyrochar electrode using HTC process water across the external loads

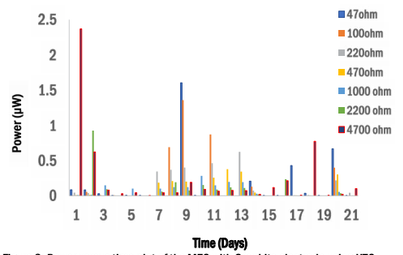


Figure 3: Power versus time plot of the MFC with Graphite electrode using HTC process water across the external loads

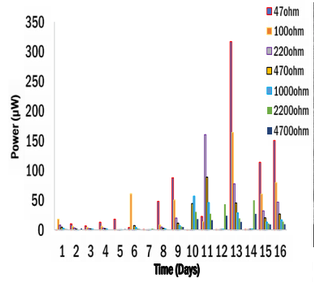


Figure 4: Power versus time plot of the MFC with KOH-activated corncob pyrochar electrode using biogas digestate across the external loads

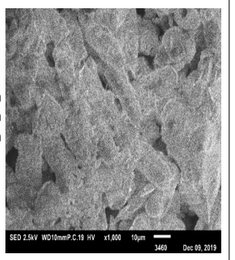


Figure 5: Electron micrograph of *S. oneidensis* biofilms on the MFC anode electrode

CONCLUSION

- ❖Electrode materials of biobased origin could be used for electricity generation in MFC using wastewaters of different origin.
- ❖The KOH activated corncob pyrochar having the highest surface area plausibly demonstrated the best MFC performance compared to the other electrodes.
- ❖Despite graphite rod electrode being a good conductor, its lowest performance might be due to its low surface area and porosity required for microbial biofilms development.

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartner*innen: Musa Bishir | E-Mail: musa.bishir@uni-hohenheim.de | Telefon: +49 (0)152 1930-1670

[1]Department of Conversion Technologies of Biobased Resources, University of Hohenheim, Garbenstraße 9, 70599 Stuttgart, Germany
[2]Institute of Biology, University of Hohenheim, Garbenstraße 30, 70599, Stuttgart, Germany

UNIVERSITÄT HOHENHEIM
DAAD Deutscher Akademischer Austausch Dienst German Academic Exchange Service
PETROLEUM TECHNOLOGY DEVELOPMENT FUND PTDF

18th September, 2020 | 13:30 - 14:45

Eugen Aschenbrenner, Karlsruher Institut für Technologie

Influence of intraparticle processes on the simulation of fast pyrolysis of biomass in an auger reactor

Eugen Aschenbrenner, Axel Funke
Karlsruher Institut für Technologie
Kaiserstraße 12
73121 Karlsruhe
E-Mail: **eugen.aschenbrenner@kit.edu**

Fuels from biomass are one way of replacing fossil fuels in the transport sector in a largely CO2-neutral way. In order not to compete with food production, mainly biomass from lignocellulose should be converted into fuel. The bioliq® process is one of the projects with which the production of biofuels up to pilot scale is being investigated in greater detail. This is a multi-stage process chain that is used to process biomass such as straw into second-generation synthetic fuels. In the first step, the straw is converted into an energetically compressed bioslurry by means of fast pyrolysis. This bioslurry is cheaper to transport and enables efficient entrained flow gasification and subsequent synthesis. The rapid pyrolysis takes place in a twin screw reactor at temperatures of 500 °C. The shredded biomass is mixed with the heat-carrier and is converted to pyrolysis vapours and coke within a few seconds. In contrast to fluidized bed reactors, the influences of operating conditions and particle properties are not yet so well understood and need to be investigated in more detail. The question arises as to what influence the intraparticle processes have on the pyrolysis process. For example, biomass is a poor heat conductor, which leads to temperature gradients within the particle, which are also anisotropic. These gradients are significantly influenced by shape and size of the particles. Lignocellulose biomass also consists of three main components that decompose at different rates. Mass transport within the particles is also important, since secondary reactions take place if the residence time is too long, which reduces the yield. How important all these processes for the product yields of the pyrolysis are, is heavily dependent on the particle size and shape. But under some circumstances, e.g. if the particles are small enough, these processes could be neglected. Therefore, the present work investigates under which conditions intraparticle processes have a significant influence and how they can be modelled. In order to investigate the different processes and their influencing parameters, a CFD-DEM model for fast pyrolysis in the twin screw reactor will be developed and validated, using the open source software package CFDEM®coupling. It couples flow simulation (CFD - Computational Fluid Dynamics) with particle simulation (DEM - Discrete Element Method). The capabilities of the existing functions have been extended, e.g. to enable computing mass sources from reactions and the use of a compressible fluid. For validation, the intraparticle processes in the simulation are to be examined in more detail and available models in the literature will be checked for accuracy and computational effort. To validate the mixing behaviour, experiments with a cold reactor will be used. A parameter study and sensitivity analysis with the developed model will help with improving the reactor design of the auger reactor, and finding critical process parameter.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

INFLUENCE OF INTRAPARTICLE PROCESSES ON THE SIMULATION OF FAST PYROLYSIS OF BIOMASS IN AN AUGER REACTOR

Eugen Aschebrenner[1], Axel Funke[1], Nicolaus Dahmen[1]

MOTIVATION

The produced fuels from non-food biomasses like wheat straw, miscanthus and wood chips, are an option of reducing the fossils fuels consumption in the transport sector. The pyrolysis of biomass is one of the ways of producing these so called second-generation biofuels.
There exist different types of reactors like the fluidized bed or auger reactor, where in most cases the biomass is mixed with a heat carrier. During the pyrolysis different processes inside the biomass particles take place. These include anisotropic heat and mass transfer, as well as primary and secondary reactions of the different components. Including these effects in the already computationally demanding models would further increase the simulation time. But under some conditions, like in the case of fast pyrolysis, they could be ignored.

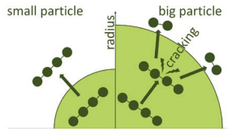


Figure 1: If the mass transport inside the particle is too slow, secondary reactions can take place which reduce the product yield

AIM

The goal of this work is to determine if the intraparticle processes can be neglected for the fast pyrolysis.

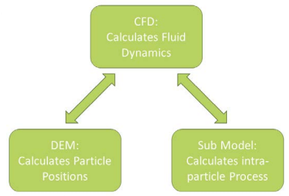


Figure 2: Coupling method of the model, the sub model calculates the amount of released gases for each particle and forwards the information. The Computational Fluid Dynamics (CFD) and Discrete Element Method (DEM) handle the fluid and particles

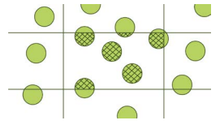


Figure 3: Each cell for the fluid simulation counts how many particles are inside of it, if a particle is in multiple cells, only a part of it is counted. As an example the hatched areas show, which parts count to the middle cell

Approach

To simulate the pyrolysis process, the Euler-Lagrange method is used. Here the fluid is treated as a continuum, while the biomass and heat carrier particles are treated as discrete elements. This way it is possible to track every single particle by itself.
For the intraparticle processes, the existing code basis was extended by coupling it with MATLAB®. This way the integration of different intraparticle models is easier because it is mostly independent from the CFD (Computational Fluid Dynamics) and DEM software (Discrete Elements Methode) and only sends relevant data for the heat and mass transfer.

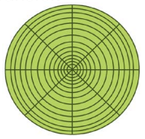


Figure 4: Example of a fully discretized particle

Figure 5: Example where only the boundaries between the layers are tracked

INTRAPARTICLE SUBMODEL

There are different ways to model the intraparticle processes, one is to fully discretize the particle, another one is to only track the boundaries of different layers that emerge during pyrolysis. For example a layer for the wet and dried biomass, char and possibly ash.
This different possibilities need to be investigated in regards to the accuracy and the computational cost. The latter becomes more important for simulations with high amounts of particles.

Karlsruher Institut für Technologie | Kaiserstraße 12 | 76131 Karlsruhe | www.kit.edu
Ansprechpartner*innen: Eugen Aschenbrenner | E-Mail: eugen.aschenbrenner@kit.edu | Telefon: +49 (0)721 608-26505

[1] IKFT, Thermochemical Conversion, Karlsruhe

18th September, 2020 | 13:30 - 14:45

Roy Nitzsche, Deutsches Biomasseforschungszentrum

Purification and valorization of C5-sugars from wood hydrolysates using hydrothermal processes and membrane filtration

Roy Nitzsche, Jakob Köchermann, Arne Gröngröft
TU Berlin
Straße des 17. Juni 135
10623 Berlin
Phone: +49 (0)341 2434-574
E-Mail: **roy.nitzsche@dbfz.de**

The utilization and conversion of lignocellulosic biomass to fuels and chemicals can help to cope with energy shortage, decreasing petroleum reserves and increasing climate change. By means of biorefineries, lignocellulosic raw materials can be fractionated in its three main constituents cellulose, hemicellulose and lignin. An appropriate process for the fractionation is the organosolv process, due to relatively mild process conditions and easy-to-recover solvents. The solid cellulose fraction is separated and can be processed to pulp. From the liquid phase, dissolved lignin is precipitated and can be used as additive in binding agents. The residual liquid fraction, so-called wood hydrolysate (WH), contains relevant amounts of hemicellulose and its monomeric degradation products. Due to low concentrations and inhomogeneous composition, this process stream has so far not been used. Aim of the research is the development and demonstration of conversion and separation cascades, which enable the material use of WH from an organosolv pulping, in particular for subsequent fermentation processes.

A relevant proportion of the hemicellulose in the WH was found in the form of dissolved oligo- sugars. A continuous hydrothermal process was therefore tested and optimized to hydrolyze the remaining oligomers into monomeric C5-sugars without further conversion to furfural, acetic acids or other chemical successors. Results showed conversion rates over 95% under mild hydrothermal conditions. More severe reaction conditions led to the formation of solid humins, which can subsequently lead to clogging of the reactor system. Therefore, regarding the avoidance of humin formation it is eminent to know the composition of the WH as well as the right process parameters (temperature, residence time, pH-value). The hydrothermally treated WH contains beneath monomeric C5-sugars components such as furfural, 5-HMF, acetic acid and phenols, which can have strong inhibitory effects in subsequent fermentation processes. By means of adsorption and the membrane technology nanofiltration (NF) the purification of this process stream into a fermentable C5-sugar stream was investigated.

Phenols could be removed by adsorption on polymeric resins to 95% with a maximum C5-sugar loss of 8%. The process of nanofiltration was initially considered with varying process parameters (pressure, temperature and cross fl ow velocity) and for different membrane properties (material and MWCO). With the appropriate membrane and process parameters C5-sugar retention of 96%, acetic acid retention of 4% and 5-HMF and furfural retention of less than 30% could be observed.

The processes and process chains developed in this way lead to higher yields of monomeric C5 sugars in higher purity and concentration, which makes it possible to use this process stream in subsequent applications.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Purification and valorization of C5 sugars from wood hydrolysates using hydrothermal processes and membrane filtration

Roy Nitzsche, Jakob Köchermann

Background & aim

A common approach to utilize lignocellulosic feedstock in biorefineries is first to apply a pretreatment that allows to separate the main components cellulose, hemicellulose and lignin. For most applications the focus is on utilizing the cellulose or the lignin. However, usually a process stream rich in sugar oligomers and monomers, as well as other degradation products from hemicellulose accrues during the pretreatment. Within the study a process configuration consisting of adsorption, hydrothermal treatment and nanofiltration was developed for the purification and valorization of monomeric C5 sugars (Fig. 1). The objects of investigation are (i) adsorption materials and mechanisms, (ii) optimization of a hydrothermal process for the conversion of oligo-sugars to mono-sugars and (iii) performance and fouling analysis of nanofiltration.

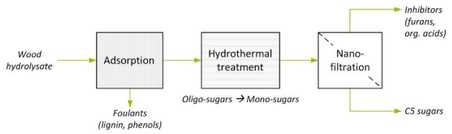


Figure 1: Schematic illustration of the developed process configuration

Adsorption

of lignin and hemicellulose sugar from beech wood hydrolysate was investigated using the polymeric resin SP700. Adsorption isotherms were measured by batch equilibrium experiments with solid-to-liquid ratios of 1:5 to 1:33 w/v. The multi-component model extended Freundlich was best fitted to the obtained data. Breakthrough and effect of flow rate were investigated in column experiments (Fig. 2). The elongated atypical shape of the lignin breakthrough curves result from the heterogeneous composition. Breakthrough of hemicellulose sugar occurred right after the first bed volume. The flow rate was found to have no effect on the adsorption.

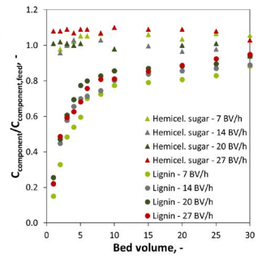


Figure 2: Effect of flow rate on breakthrough curve of lignin and hemicellulose sugar with SP700 bed

Hydrothermal treatment

of oligo-xylose from beech wood hydrolysate to xylose was investigated using the response surface methodology. The considered variables were temperature and residence time. A pressure of 5.0 MPa was set for all trials. Observed responses were oligo-xylose, xylose and furfural concentration. The interaction between temperature and residence time has a significant influence on the conversion products of oligo-xylose (Fig. 3). While short residence times at elevated temperatures lead to high yields of xylose, at long reaction times and moderate temperatures degradation products such as furfural are already formed. Optimal process parameters for maximum conversion of oligo-xylose to xylose were a temperature of 180°C and a residence time of 3.1 min.

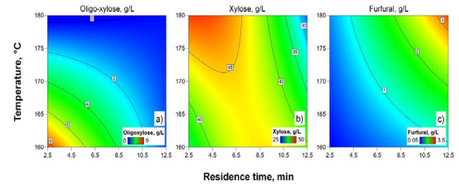


Figure 3: Contour plots of a) oligo-xylose, b) xylose, and c) furfural concentration versus temperature and residence time

Nanofiltration

was investigated for the separation and concentration of monomeric xylose from fermentation inhibitors (e.g., furans and acetic acid) out of hydrothermally treated beech wood hydrolysate. Nanofiltration (NF) was conducted at a transmembrane-pressure of 3.0 MPa, temperature of 35°C and cross flow velocity of 1.1 m/s to a volume reduction of 80% (Fig. 4). Thereby, the xylose concentration in the retentate increased 4.8-fold and the inhibitor-to-xylose ratio decreased 3.4-fold.

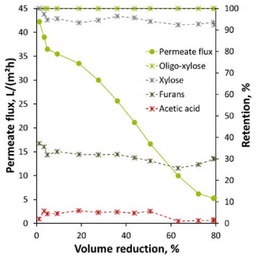


Figure 4: Flux and component retentions during the NF of hydrothermal treated beech wood hydrolysate

Conclusion The applicability of a process configuration consisting of adsorption, hydrothermal treatment and nanofiltration for the purification and valorization of wood hydrolysates was demonstrated. This approach shows great potential due to low energy and auxiliary consumption and thus lower costs and environmental impacts compared to conventional processes.

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Straße 116, D-04347 Leipzig, www.dbfz.de
Contact person: Roy Nitzsche
E-Mail: roy.nitzsche@dbfz.de, Phone: +49 (0)341 2434-574

Funded by: Federal Ministry of Education and Research

18th September, 2020 | 13:30 - 14:45

Jürgen Loipersböck, BEST - Biomass and Sustainable Technologies

Improvements in the gas cleaning of a biomass based hydrogen production plant

Jürgen Loipersböck, Reinhard Rauch, Hermann Hofbauer
TU Wien
Getreidemarkt 9
1060 Wien
E-Mail: **juergen.loipersboeck@best-research.eu**

The hydrogen demand has risen constantly over the past decade. To accomplish the goal of a green hydrogen economy, environmentally friendly and CO_2 neutral production methods are needed. In 2008, 96% of the hydrogen was produced from fossil fuels, and only a small share of 4% has been produced by electrolysis and other renewable technologies. As main hydrogen users the ammonia production, refinery processes and methanol production can be stated. Other users like steel production and mobility are likely to increase their demand over the next years. 2010 Zakkhour et al. estimated the hydrogen consumption to reach 58 Mt annually in the year 2025. This value has already been outreached in 2013 according to the International Energy Agency. Currently, the world-wide hydrogen consumption is estimated with up to 65 million tons per year. One possibility of producing renewable hydrogen is biomass gasification. Biomass based hydrogen is a highly valuable product from the ecological point of view. However, economical seen hydrogen from biomass is still not competitive to matured fossil production methods. Therefore, an extensive study regarding the mass- and energy balance of a bio hydrogen plant was done. Lab data was validated to calculate the mass- and energy balance of a 10 MW hydrogen production plant. This data was used to identify the most energy and material consuming process steps, the CO_2 removal and the tar removal. A special focus in this work was laid on the tar removal, to develop an energy and material saving fine gas cleaning for further improvement of the biomass to hydrogen technology. To investigate the behaviour of tar components, typical gas compositions - derived from an industrial dual fluidised bed gasifier, were used. An experimental investigation regarding adsorption and desorption behaviour was done, leading to a temperature swing adsorption unit. This unit was tested during several hundred ad- and desorption cycles, showing a good stability. A high tar removal of over 95% could be confirmed in the test runs, establishing a tar dew point between -14 to -9°C and giving the opportunity to remove tars and sulphur in one step. These results were compared with the benchmark for tar removal from biomass derived syngas, the biodiesel scrubbing, where a tar dew point of -6°C could be achieved. Beside the reduced tar dew point and the additional sulphur removal, the adsorption-based gas cleaning also allows a hydrogen production plant, to run with reduced consumables, making it economically more feasible. First results of the setup show the possibility of separating the BTX compounds, allowing a valorisation of them.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Improvements in the fine gas cleaning of DFB syntheses plants

Jürgen Loipersböck[1,2], Reinhard Rauch[3], Hermann Hofbauer[2]

INTRODUCTION

Gasification can be seen as key technology for a sustainable future. Dual fluidised bed (DFB) gasification offers the possibility to convert a various amount of feedstocks (e.g., wood, sewage sludge, residues) into a nitrogen lean product gas which is highly suitable for syntheses applications. However, impurities produced during gasification can cause problems during compression and catalysed processes. In this work an adsorption based gas cleaning system, to remove condensable hydrocarbons (tar) and sulphur, is presented. Figure 1 shows a typical process setup of a DFB plant used for syngas applications.

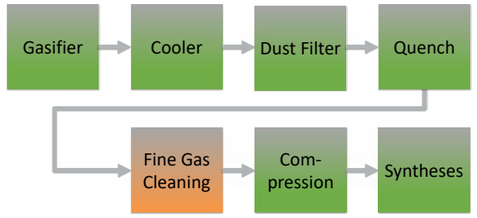


Figure 1: Block flow chart of DFB plant for syngas applications

The plant consist of a DFB gasifier, a cooler, a dust removal and a quench (commonly a biodiesel scrubber) to remove high molecular hydrocarbons. The fine gas cleaning is used to remove low boiling aromatic compounds, which may cause condensation problems and sulphur impurities which cause catalyst poisoning. Thereafter, a compression is applied and the gas can be send to the syntheses application. The previous gas cleaning approaches were absorption based and produced high amounts of solvent for disposal. Therefore, a novel adsorption based fine gas cleaning was developed to allow a cost reduction and increase the syngas quality.

MATERIAL & METHODS

The novel fine gas cleaning was developed by an experimental approach. Based on the standard tar composition after the quench, model tar compounds were identified and adsorption isotherms were measured and modelled for several temperatures. A temperature swing adsorption (TSA) was designed and long term tests were executed.

RESULTS & CONCLUSION

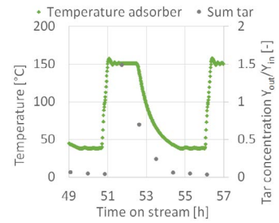


Figure 2: TSA temperature and concentration profile

TSA	
Tar dew point	-14.3 to -2.8°C
Tar rem. eff.	96 to 99 %
Heat duty	45 MWh/aMW
Cool duty	185 MWh/aMW

Table 1: Process data TSA tar and water removal (based on 1 MW fuel power)

Figure 2 shows the TSA operation during 49 to 57 h on stream. In this experiment a temperatures of 40°C for adsorption and 152°C for desorption were adjusted. The tar removal efficiency could be measured with 96 to 99% and a tar dew point of up to -14.3°C could be achieved (Table 1).

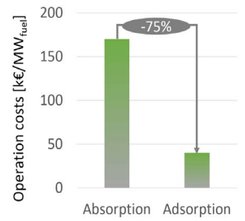


Figure 3: Cost reduction potential of the novel TSA gas cleaning

Figure 3 shows the cost reduction potential of the novel gas cleaning. An OPEX reduction of 75% could be achieved, making the TSA based gas cleaning unit highly valuable for DFB based syntheses plants.

BEST – Bioenergy and Sustainable Technologies GmbH | Inffeldgasse 21b | 8010 Graz | www.best-research.eu
Contact: Jürgen Loipersböck | juergen.loipersboeck@best-research.eu | + 43 5 02378-9357

[1] BEST – Bioenergy and Sustainable Technologies, Syngas applications, Graz
[2] TU Wien, Institute of Chemical, Environmental and Bioscience Engineering, Vienna
[3] Karlsruhe Institute of Technology, Institute of Chemical, Environmental and Biological Engineering, Karlsruhe

BEST Bioenergy and Sustainable Technologies

18th September, 2020 | 13:30 - 14:45

Sevim Özgül, Ege University, Solar Energy Institute

Evaluation of the vineyards with the biorefinery approach

Sevim Özgül[1], Pınar Büyük Taban[1], Ahmet Eryaşar[2], Günnur Koçar[2]
[1]Ege University, Solar Energy Institute
35100 Izmir, Turkey
E-Mail: **sevimozgul88@gmail.com**

[2]Biomass Energy Systems and Technology Research and Application Center (BESTMER), Ege University, İzmir, Turkey

Due to the abundance of agricultural wastes, easy accessibility, eco-friendly, renewability and sustainable development the interest in evaluating of agricultural wastes for production of energy, biofuels and materials has increased. In this study, vineyard waste was used as a biomass raw materials. To achieve valuable products such as biochar, syngas, and various liquid hydrocarbons, torrefaction and pyrolysis process were conducted. Torrefaction was conducted with the temperature (250, 300, 350 °C) and residence time (30, 60, 90 min) and pyrolysis process was done with the temperature (400, 450, 500 °C), residence time (30, 60, 90 min). The effects of the temperature and residence time on the properties, composition, and yield of the biochar obtained were observed to evaluate the optimization of the torrefaction and pyrolysis process. Mathematical models were developed to explain on the weight yield, HHV and ash content and experimental data were analyzed by analysis of variance (ANOVA). Also, the amount of tar obtained from the experiment where the highest gas was obtained was calculated using the gravimetric analysis method. Moreover, thermogravimetric analysis were conducted for determine the thermal behavior of biochar. In addition, liquid hot water (LHW) and acid pretreatment were applied to determine the monosaccharides and its degradation products for ethanol production. Experiments of LHW were carried out by varying temperature (140 160 and 180 ºC), reaction time (30 and 60 min) and acid pretreatment was studied with temperature (90, 105 and 120ºC), sulfuric acid concentration (1, 1.5 and 2 w/w) and residence time (1, 2 and 3 h). As a result, the potential of vineyard waste via biorefinery approach found out. The highest sugar amount of LHW is 77 50 g/L, while it is 208 48 g/L for sulfuric acid pretreatment. Also, the highest gas yield was obtained at 500 ºC-90 min and the mass balance of this experiment is 65.5% biochar, 7.75% pyrolysis liquid, and 26.75% gas product. Moreover, the highest calorific value of biochar was obtained at 400 ºC-60 min and it is 5943.76 cal/g. Evaluating vineyard waste via biorefinery approach is significant due to huge potential in Turkey and these findings may be a guide for further researches.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Evaluation of the vineyards with the biorefinery approach

Sevim Özgül[1], Pınar Büyük Taban[1], Ahmet Eryaşar[2], Günnur Koçar[2]

Abstract

Due to the abundance of agricultural wastes, easy accessibility, eco-friendly, renewability and sustainable development the interest in evaluating of agricultural wastes for production of energy, biofuels and materials has increased. Turkey is homeland of the grapevine (Vitis spp.), one of the most important agricultural products in the World. Our country, having the favorable climatic conditions for viticulture, has an important role among the viticulture farming countries of the World. Also, the waste potential of vineyards is 250-384 kg/decare [1]. The objective of this study is to determine potential of the vineyards waste in terms of bioenergy. To achieve valuable products such as biochar, syngas, and various liquid hydrocarbons, torrefaction and pyrolysis process were conducted. Torrefaction was conducted with the temperature (250, 300, 350 °C) and residence time (30, 60, 90 min) and pyrolysis process was done with the temperature (400, 450, 500 °C), residence time (30, 60, 90 min). Also, in this study, liquid hot water (LHW) and acid pretreatment were applied to determine the monosaccharides and its degradation products for ethanol production. Experiments of LHW were carried out by varying temperature (140, 160 and 180 °C), reaction time (30 and 60 min) and acid pretreatment was studied with temperature (90, 105, 120 °C), sulfuric acid concentration (1, 1.5, and 2% w/w) and residence time (1, 2, and 3 h). As a result, the potential of vineyard waste via biorefinery approach found out. The highest sugar amount of LHW is 77.50 g/L, while it is 208.48 g/L for sulfuric acid pretreatment. Also, the highest gas yield was obtained at 500 °C-90 min and the mass balance of this experiment is 65.5% biochar, 7.75% pyrolysis liquid and 26.75% gas product. Moreover, the highest calorific value of biochar was obtained at 400 °C-60 min and it is 5943.76 cal/g. Evaluating vineyard waste via biorefinery approach is significant due to huge potential in Turkey and these findings may be a guide for further researches.

Material & Methods

The vineyards waste was obtained from Manisa province of Turkey. The moisture content of the vineyards waste was approximately 16 wt%. The waste was dried in an oven at 80 °C for 24 hours. The moisture content, volatile matter and ash content of the waste were determined according to ASTM D 3172-89 standard. Also, the higher heating value (HHV) of waste and total organic carbon (TOC) were measured. Table 1 shows the results of proximate analysis, HHV and TOC.

	Moisture %	Ash %	Volatile matter %	TOC %	HHV (cal/g)
Raw material	15.95	7.8	92.2	45.91	4450.49

Table 1: The results of proximate analysis, HHV and TOC.

LHW was carried out on the dried cotton stalk in 1 dm^3 Erlenmeyer flasks (100 g water and 10 g vineyard waste in each flask) at three different temperature (140 °C, 160 °C and 180 °C) for 30 and 60 min in an oven. After the pretreatment, the hydrolysates were collected and stored at 4 °C. Also, in this study, Box Behnken design, with three levels and three center points, was used in the study for acid pretreatment. Thus, the number of experiments was obtained 15 runs. In addition, Torrefaction and pyrolysis experiments were carried out in a batch stainless steel reactor (length 80 cm and diameter 5.08 cm) at 250 °C, 300 °C, 350 °C, 400 °C, 450 °C and 500 °C by a 2.5 kW electrical heater. When the reactor desired temperature reached, the sample was kept in the reactor for 30, 60, 90 min. At the end of experiments, the reactor temperature was cooled to below 150 °C in atmosphere and then the biochars were collected and weighted. The biochars were stored in plastic containers for further analysis. Also, the amount of tar of highest gas yield experiment was calculated according to the Lambert Beer law.

Results and discussion

The results of the total sugar concentration of LHW pretreatment and acid pretreatment are shown in figure 1 and table 2 respectively. The highest sugar amount of LHW is 77.50 g/L, while it is 208.48 g/L for sulfuric acid pretreatment. Comparing LHW and sulfuric acid, it is observed that sulfuric acid pretreatment is more effective in obtaining sugar.

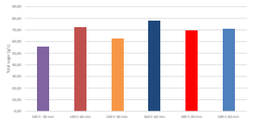


Figure 1: The total sugar concentration of LHW pretreated vineyards waste

Run	Temperature (°C)	Sulfuric acid concentration (%)	Residence time (h)	Response Total sugar (g/L)
1	120	1.5	1	175.01
2	105	2	3	64.45
3	90	1.5	3	182.76
4	90	2	2	11.94
5	105	1.5	2	116.43
6	120	2	2	115.92
7	105	1.5	2	121.83
8	105	1	1	14.29
9	120	1.5	3	31.15
10	105	1.5	2	153.11
11	90	1.5	1	173.73
12	105	2	1	208.48
13	105	1	3	179.65
14	120	1	2	125.27
15	90	1	2	173.74

Table 2: The total sugar concentration of sulfuric acid pretreated vineyards waste

In the thermal experiments, with the increase in temperature, the amount of gas output also increased. According to the study results, the highest gas yield was obtained at 500 °C-90 min. Figure 2 shows the amount of gas released with increasing temperature.

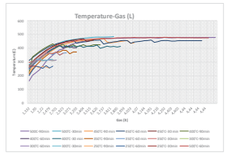


Figure 2: The amount of gas released with increasing temperature.

Reference
[1] Republic of Turkey Ministry of Agriculture and Forestry Viticulture Research Institute

Also, the main reason for obtaining quality biochar at low temperatures is that the carbon amount is not transferred to the gas phase. Figure 3 shows the relation of temperature and gas amount of the 500 °C-90 min which has highest gas yield. According to results, the highest calorific value is obtained in the experimental study performed at 400 °C-60min. In addition, the total organic carbon and calorific value relationship is shown in figure 4. It is known that as the amount of carbon increases, the calorific value also increases.

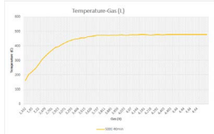


Figure 3: The relation of temperature and gas amount of the 500 °C-90 min

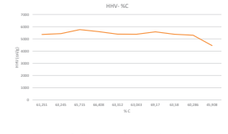


Figure 4: The total organic carbon and calorific value relation

The amount of tar obtained from the 500 °C-90 min study where the highest gas was obtained was calculated using the gravimetric analysis method. According to the Lambert-Beer law the tar content of 500 °C-90 min was determined and figure 5 shows the content of the tar. Also, thermogravimetric analysis (TGA) of the raw material, 500 °C-90 min, and 400 °C-60 min were measured from 30 °C to 720 °C at a rate of 20 °C/min under argon flow and the results are shown in figure 6. As the temperature and residence time was increased, mass loss was increased too. The mass loss for raw material was 63.896% while it was 25.758% for 400 °C-60 min and was 31.702% for 500 °C-90 min. The thermal degradation potential of raw material up to 720 °C is approximately 64%. Mass loss during thermal decomposition is related to the carbon content. Less mass loss occurs during thermal decomposition for biochar with high carbon content. While the TOC is 63.587% for 500 °C-90 min, it is 71.803% for 400 °C-60 min.

Figure 5: The content of the tar of 500 °C-90 min

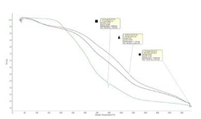


Figure 6: TGA analyses of the raw material, 500 °C-90 min, and 400 °C-60 min.

Conclusion

In this study, it is aimed to determine potential of the vineyards waste in terms of bioenergy. It has been observed that acidic pretreatment is a more effective method for obtaining sugar. Also, some experiments were carried out to determine the thermal degradation potential of vineyards waste and to compare the resulting products. In these experiments, torrefaction and pyrolysis thermal conversion methods were studied. As a result of the experiments, it is seen that the temperature rise, time and type of raw material are among the most basic parameters that determine the product quality of thermal conversion processes. The quantities and qualities (calorific value and carbon content) of solid and gas products of thermal process were compared. While an increase in the amount of gas product is observed with the increase of temperature and time, the product direction shifts to the solid phase with the decrease in temperature. At temperatures below 400 °C, sufficient environment could not be provided for the start of thermal processes.

Corresponding Author: Sevim Özgül | E-Mail: sevimozgul88@gmail.com | Telefon: +90 537 448 01 98

[1] Solar Energy Institute, Ege University, 35100 Izmir, Turkey

[2] Biomass Energy Systems and Technology Research and Application Center (BESTMER), Ege University, Izmir, Turkey

18th September, 2020 | 13:30 - 14:45

Sonya Barzgar, Empa

The effect of pH, Ca/Si ratio and equilibration time on Al up-take in calcium silicate hydrates (C-S-H).

Sonya Barzgar
École polytechnique fédérale de Lausanne
Route Cantonale, 1015 Lausanne
Phone: +41 58 765 4429
E-Mail: **sonya.barzgar@empa.ch**

1. Introduction

Cement production accounts for approximately 6% of man-made CO2 emissions. To reduce these emissions, Portland cement (PC) is partially replaced by supplementary cementitious materials (SCM) such as ashes from thermal waste treatment [1]. Reaction of SCM with PC during hydration leads to the formation of calcium silicate hydrates (C-S-H), which is the most important phase in cements based on silica-rich SCM [2]. The high Al2O3 and SiO2 con-tent of the SCM results in C-S-H compositions with more Si and Al than in PC which affects the stability and durability of such concrete. In the presence of Al in the solution, C-S-H is able to incorporate Al to produce what is generally called C-A-S-H.

2. Approach and methods

In this study, the Al sorption isotherms are investigated at different NaOH concentrations, Ca/Si ratios and equilibration times. During synthesis, different quantities of CaO, SiO2 and CaO. Al2O3 were added into NaOH solutions to obtain C-A-S-H with different compositions. Af-ter equilibrating for 3 months, 1 year, 2 years and 3 years samples were filtrated and the el-emental concentrations of Ca, Si and Al in the filtrates were determined with inductively coupled plasma mass spectrometry (ICP-OES).

3. Results

Al sorption isotherms at different NaOH concentrations indicated the higher dissolved con-centrations of Al at higher pH values pointing towards a less uptake of Al in C-S-H. Moreover, a higher Al uptake in C-S-H was observed at higher Ca/Si ratios, which indicates a stabilizing effect of Ca in the interlayer on Al uptake [3]. Furthermore, the decrease in the dissolved concentration of Al over increasing the equilibration time represented a slow reaction of Al in the C-S-H structure leading to the more Al uptake in C-S-H over time.

4. Conclusion

In this study, the effect of pH, Ca/Si ratio and equilibration time on Al uptake in C-S-H was investigated by ICP-OES. The determination of sorption isotherms revealed that Al uptake in C-S-H is increased at lower pH values, higher Ca/Si ratios and higher equilibration times.

References:
[1.] B. Lothenbach, K. Scrivener, R.D. Hooton, Supplementary cementitious materials, Cem. Concr. Res. 41 (2011) 1244–1256.
[2.] B. Lothenbach, A. Nonat, Calcium silicate hydrates: Solid and liquid phase composition, Cem. Concr. Res. 78 (2015) 57–70.
[3.] S. Barzgar, B. Lothenbach, M. Tarik, A. Di Giacomo, C. Ludwig, The effect of sodium hydroxide on Al uptake by calcium silicate hydrates, J. Colloid Interface Sci. 572 (2020) 246–256.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

The effect of pH, Ca/Si ratio and equilibration time on Al uptake in calcium silicate hydrates (C-S-H)

Sonya Barzgar, Barbara Lothenbach, Mohamed Tarik, Christian Ludwig

INTRODUCTION

Cement production accounts for approximately 5% of man-made CO_2 emissions. To reduce them, biomass and wastes are used as energy carriers. In addition, ashes and slags can also partially replace cement. These substitutes are called supplementary cementitious materials (SCM). However, high Al_2O_3 and SiO_2 contents in SCM affect the stability and durability of such cements. Here we study the role of Al on calcium silicate hydrates (C-S-H), which is the most important phase in cements based on silica-rich SCM, to predict the formed hydrate phase assemblages and their effects on durability. The composition of C-S-H incorporating aluminum "C-(A)-S-H" as a function of different parameters such as Ca/Si ratio, equilibration time and alkali contents were investigated.

MATERIAL AND METHODS

- Total 3.8 g of CaO, SiO_2 and $CaO.Al_2O_3$ in 171 ml of water or NaOH solution.
- Preparation inside a N_2 filled glovebox.
- Freeze-drying during one week and then storing until analysis in nitrogen filled desiccators.
- Equilibration for different times at 20 ° C.
- Filtration of samples inside the glovebox after 3 months, 1 year, 2 and 3 years equilibration.
- Measurement of elemental concentrations of Ca, Si, Al and Na in the liquid phase with ICP-OES.

Ca/Si	Al/Si	NaOH (mol/L)
0.6, 0.8, 1, 1.2 and 1.4	0	0
	0.001	0.1
	0.003	0.5
	0.01	1
	0.03	
	0.05	
	0.1	

Table 1: Ca/Si, Al/Si ratio and alkali concentrations used to prepare C-A-S-H at 20° C.

CONCLUSION

- The presence of alkali hydroxide leads to higher pH values and less uptake of Al in C-S-H.
- Increasing the Ca/Si ratio leads to an increase of the Al uptake in C-S-H.
- Higher uptake of Al was observed after longer equilibration times.

ACKNOWLEDGMENTS

The financial support of Swiss National Science Foundation (project No. 200021_169014) is gratefully acknowledged.

RESULTS

- The presence of NaOH increases the pH and leads to much higher Al concentrations in solution.
- High pH leads to more negative charge on C-S-H surface as well as the predominance of $[Al(OH)_{4\,(aq)}^-]$ in solution which results in less Al uptake in C-S-H.

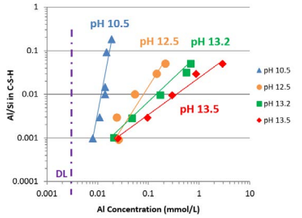


Figure 1: The Al uptake by C-S-H for Ca/Si ratio of 0.8 after 3 months equilibration.

- Higher equilibration time leads to the decrease in Al concentrations and increase in Al uptake in C-S-H.
- The change in Al concentrations in solution decreases over time indicating the equilibrium condition.

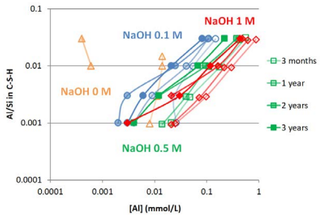


Figure 2: The Al sorption isotherm for Ca/Si ratio of 0.8 after different equilibration times.

- Increasing the Ca/Si ratio leads to an increase of the Al uptake in C-S-H.
- More Ca in the interlayer at higher Ca/Si leads to positive charge on C-S-H surface and more uptake of $Al(OH)_4^-$.

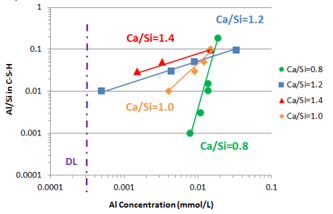


Figure 3: The Al uptake in C-S-H at different Ca/Si ratios.

Corresponding Author: Sonya Barzgar | E-Mail: sonya.barzgar@empa.ch | Telephone: +41 (0) 58 765 4429

[1] Empa, Functional Materials, Concrete & Asphalt, Dubendorf, Switzerland
[2] EPFL, Civil and Environmental Engineering, ENAC IIE GR-LUD, Lausanne, Switzerland
[2] PSI, Bioenergy and Catalysis Laboratory, Chemical Processes and Materials, Villigen, Switzerland

18th September, 2020 | 13:30 - 14:45

Joscha Zimmermann, KIT, Institute of Catalysis Research and Technology

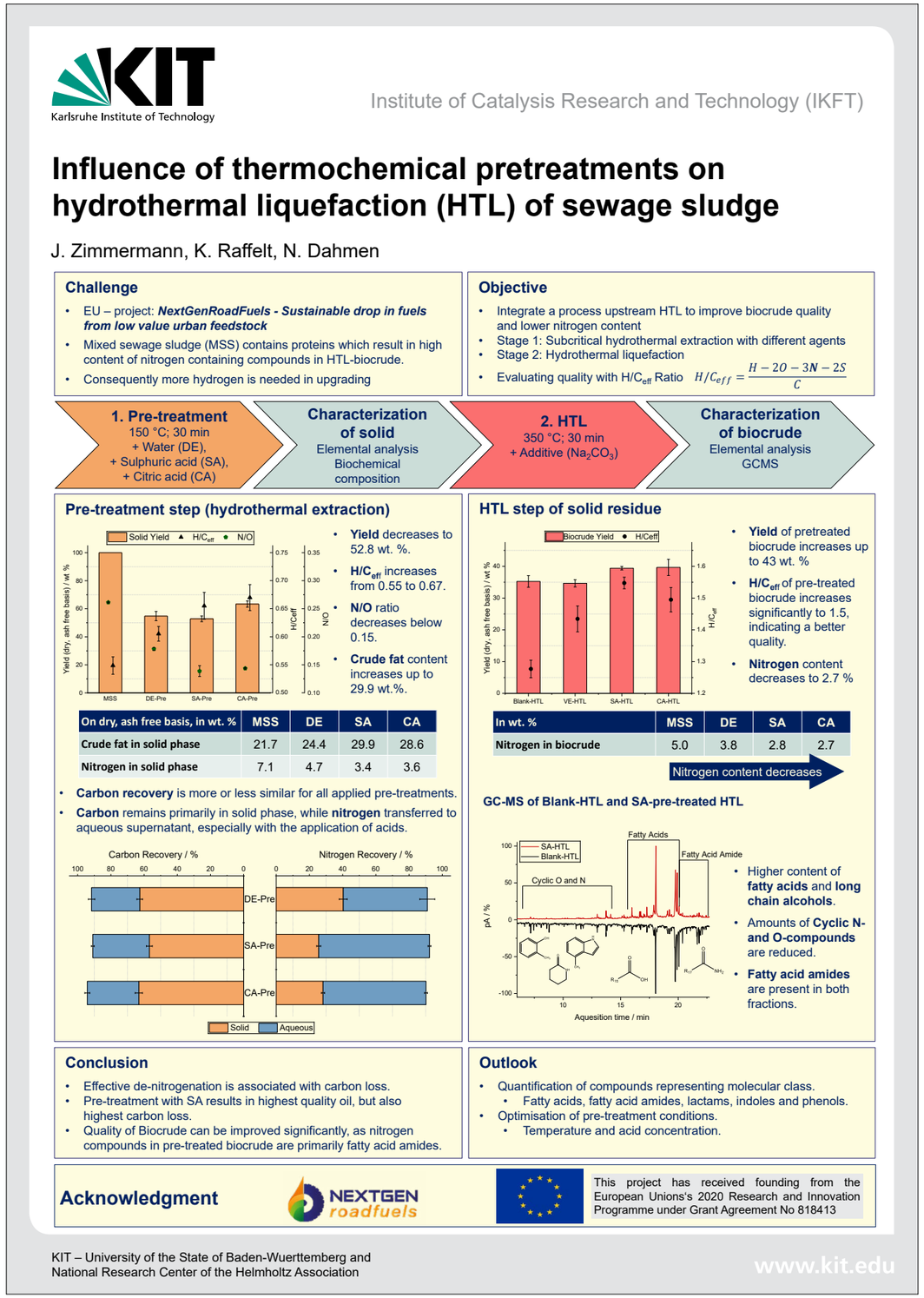
Thermochemical pre-treatments for the hydrothermal liquefaction of sewage sludge

Joscha Zimmermann, Dr. Klaus Raffelt, Nicolaus Dahmen
Karlsruhe Institute of Catalysis Research and Technology
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
E-Mail: **joscha.zimmermann@kit.edu**

Hydrothermal liquefaction (HTL) is a thermochemical process for converting directly wet biomass and organic residues into bio-crude. This product can be applied as a drop-in transportation fuel or substitute petroleum in refi neries. Advantages of the process are high conversion rates, the catalytic effect of the reaction medium water and, consequently, the previously mentioned ability to utilize a wet feedstock like sewage sludge. Nevertheless, the production of biofuels by HTL of sewage sludge involves several problems, especially in regard to the inorganic components and the formation of heteroatomic compounds. Sewage sludge has a relatively high content of inorganics, mostly alkali and alkaline earth metallic species, which were used upstream in the wastewater treatment process. This high ash content in the feedstock is refl ected in the bio-crude yield and quality and challenges the catalytic upgrading to fuels e.g. by a decrease in catalyst activity due to poisoning and depositions. Additionally, sewage sludge is a biogenic material rich in proteins and contains, in particular, high amounts of nitrogen and sulphur. These heteroatoms can reduce the heating value, lead to un-desirable emissions and thus increase the costs for downstream processing. In this study, we investigate the infl uence of different pre-treatment methods prior to sewage sludge conversion. Different leaching-agents and temperatures are applied to transfer inorganics and organic nitrogen into the liquid supernatant. In a next step, the resulting solids will be dewatered and converted into bio-crude by HTL. Research work focuses on how the sludge changes in its physical–chemical composition by the pre-treatment, the impact on the HTL product yields as well as on the bio-crude quality.

Therefore, the bio-crude is being separated into different fractions to determine the elemental composition and, consequently, their species. The overall goal of this work is to develop an effi cient pre-treatment method for HTL of sludge. It is expected that an acid pre-treatment at ambient temperature remove inorganic constituents from the sewage sludge matrix and with rising temperature proteins start to hydrolyse and deamination reactions occur. The tretment will lower the nitro-gen, but also the carbon content in the sludge the subsequent HTL bio-crudes will have a higher quality. Additionaly the carbon recovery is investigated and correlated with the bio-crude.

This subject is embedded in the Next-GenRoadFuels project and has received founding from the European Unions‘s 2020 Research and Innovation Programme under Grant Agreement No 818413



18th September, 2020 | 13:30 - 14:45

Thomas Braunsperger, Montanuniversity Leoben

Hydrothermal liquefaction of biogenic residues and microalgae

Thomas Braunsperger, Markus Ellersdorfer
Montanuniversity Leoben
Franz-Josef-Strasse 18
8700 Leoben
E-Mail: **thomas.braunsperger@unileoben.ac.at**

In the project “Bio-HTL”, the Chair of Process Engineering and Industrial Environmental Protection (Montanuniversity Leoben, Austria) investigates the hydrothermal liquefaction of biogenic residues and microalgae. In hydrothermal liquefaction, biomass can be converted into a biological crude oil, the so-called biocrude, at 300 - 350 °C and 120 - 170 bar. Water serves as the reaction medium, reactant and catalyst in this process. During the hydrothermal liquefaction four products are formed: biocrude, a polar aqueous phase, a solid residue and a gas phase. One advantage of this technology is the use of wet biomass, which saves expensive, energy-intensive drying processes. The hydrothermal liquefaction is being investigated at the Montanuniversity Leoben by using a laboratory scale autoclave. A total of ten different biogenic residues and two strains of microalgae were characterised and liquefied. The biogenic residue samples were dried at 105 °C, crushed and then stored frozen. Each feedstock was analysed for dry matter -, lipid -, protein -, ash - and chlorine content as well as lower heating value and elemental composition. The process parameters were 350 °C at 160 - 170 bar with a holding time of 15 min. After the reaction, the autoclave was cooled to room temperature and the gas phase was analyzed by FTIR. Samples were collected and cleaned with distilled water and dichloromethane. The solid residue was separated by filtration and then the filtrate was transferred to a separating funnel. The separation of the polar aqueous phase and the apolar oil phase was done by the difference in density. The oil-containing phase was then distilled and the biocrude was recovered. The yields of the individual products were calculated via a mass balance. The obtained biocrude was examined for its lower calorific value, elemental composition and chlorine content. During the hydrothermal liquefaction of the biogenic residues biocrude yields between 9.43 m.% (green waste) and 70.40 m.% (grease separator) were achieved. The amount of derived biocrude strongly correlates with the lipid content of the input material. Furthermore, strong fluctuations were found, which are due to the heterogeneity of the biogenic residues. In comparison with the feedstock, the carbon content of each biocrude was increased and the oxygen content was significantly reduced. This also resulted in a significant increase of the lower heating value to 35 - 36 MJ/kg for the biocrude compared to the feedstock. Biogenic residues with an increased lignocellulose content (green waste) and an increased content of inorganic substances (sewage sludge) showed an increased formation of solid residue of up to 50.32 m.%. Another important part of the project is the utilization of the by-products of the hydrothermal liquefaction and the integration of the biocrude into the refinery process.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Hydrothermal liquefaction of biogenic residues and microalgae

Thomas Braunsperger, Markus Ellersdorfer

Introduction

The aim of this work was to test the possible applicability of ten biogenic residues and two strains of microalgae as feedstock for hydrothermal liquefaction (HTL). HTL is a technology to convert wet biomass into a biological oil. Additional gas, solid residue and an aqueous phase are the by-products of the process.

HTL Yields

Table 1 shows the yields from the HTL (double determinations) of biogenic residues and microalgae at 350 ° C and 15 min holding time. Biocrude yields between 9.4% (green waste) and 70.4% (grease separator) could be achieved. The biocrude yields show a significant correlation with the lipid content of the feedstocks. The lipid contents of the feedstocks determined by Soxhlet extraction are shown in Figure 1.

Table 1: HTL product yields of the different feedstocks. Sewage sludge (SS).

Sample	Biocrude [%]	Solid residue [%]	Gas [%]	Aqueouse phase [%]
Anaerobic SS 1	13,5	50,3	8,5	27,7
Anaerobic SS 2	12,8	44,3	10,8	32,1
Aerobic SS	13,8	40,5	9,9	35,8
Green waste	9,4	49,2	9,7	31,7
Organic waste	16,2	40,4	13,0	30,4
Digestate	11,0	43,1	8,7	37,2
Leftovers	34,3	19,0	13,2	33,5
Micells	34,0	20,8	12,2	33,0
Flotate	59,7	14,4	8,1	17,8
Grease separator	70,4	28,4	0,0	1,2
Chlorella Vulgaris	13,4	23,8	6,5	56,3
Spirulina	20,5	22,1	14,4	43,0

Heating values of the feedstocks and biocrude samples

The lower heating values of the dry feedstock and associated biocrude samples are shown in Figure 2. The heating values of the feedstocks ranged from 11.7 MJ/kg (fermentation residue) to 32.3 MJ/kg (grease separator), those of the Biocrude samples between 30.6 MJ/kg (Chlorella Vulgaris) and 35.85 MJ/kg (leftovers, micells). The increase of the heating values in biocrude is due to an increase of the carbon content and the reduction of the oxygen content.

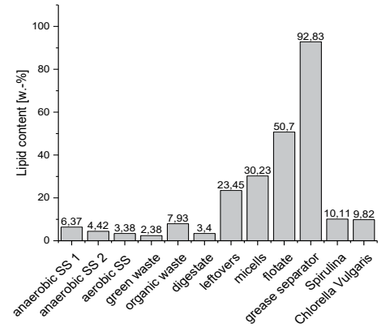


Figure 1: Lipid content of the feedstocks determined by Soxhlet extraction.

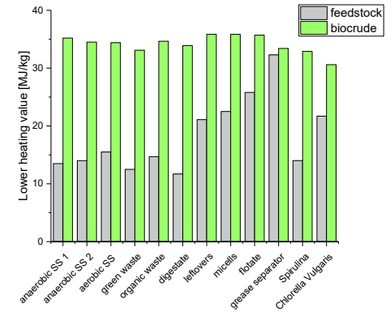


Figure 2: Lower heating value of the feedstock and its equivalent biocrude after HTL.

Conclusion and outlook

All biogenic residues and microalgae could be successfully hydrothermally liquefied. Continuing research work on this project will be:

- Co-HTL of biogenic residues in combination with microalgae
- Possible uses of the HTL by-prodcts
- Calculation of a kinetic model

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH | Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartner: Thomas Braunsperger | E-Mail: thomas.braunsperger@unileoben.ac.at | Telefon: +43 3842 402-5005

Chair of Process Technology and Industrial Environmental Protection, Department of Environmental and Energy Process Engineering, Montanuniversität Leoben

18th September, 2020 | 13:30 - 14:45

Christian Klüpfel, Deutsches Biomasseforschungszentrum

Hydrothermal liquefaction of waste biomass

Christian Klüpfel, Jakob Köchermann, Benjamin Wirth
Deutsches Biomasseforschungszentrum
Torgauer Str. 116
04347 Leipzig
Phone: +49 (0)341 2434-436
E-Mail: **christian.kluepfel@dbfz.de**

The increasing scarcity of fossil resources and the climate crisis associated with their use require sustainable solutions for supplying global energy needs. Waste biomass is a promising, renewable carbon resource. In recent years, various thermochemical processes have been applied for refining biomass, including pyrolysis, gasification, and hydrothermal processes (HTP). However, compared to other thermochemical processes, HTP have the advantage that wet biomasses do not need to be dried, since water is required as a reaction medium. One process that offers a promising path for the energetic and material exploitation of wet biomass is hydrothermal liquefaction (HTL). Biocrude obtained from HTL is a potential fuel precursor. HTL has been studied for various feedstocks, such as algae, (ligno-)cellulosic biomass, sewage sludge and manure, while digestate requires further investigation. Integrating HTL into the biogas process promises to create a value product from waste while retaining the nutrient load for fertilization. This doctorate aims to highlight the influence of parameters such as digestate feedstock, digestion time, temperature, pH, catalyst on 1) the biocrude yield and composition and 2) the nutrient distribution and recycling.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Hydrothermal liquefaction of waste biomass

Christian Klüpfel, Jakob Köchermann, Benjamin Wirth

Introduction

The increasing scarcity of fossil fuels coupled with growing world population calls for renewable solutions for meeting global energy needs. The project “Pilot-SBG“ seeks to improve the production of methane from biogenic residues, by-products, and wastes by opening up hitherto untapped resources and optimizing the utilization of developed resources. This is to be achieved by combining established processes (see Figure 1).

In this context, hydrothermal liquefaction (HTL) shall be used to treat the product of anaerobic digestion. Hydrothermal liquefaction is the thermochemical conversion of wet biomass in hot, compressed water. It is typically performed in subcritical conditions (T = 523-647 K, p = 4-22 MPa). First biomass is depolymerized by hydrolysis, the monomers further decompose by decarboxylation and dehydration and subsequently recombine by polymerization and polycondensation. This yields an energy-dense biocrude, an aqueous fraction rich in nutrients, a gas-phase mainly comprised of CO_2, and a solid fraction containing hydrochar as well as insoluble components. Benefits of implementation include the creation of a renewable fuel, recycling of nutrients and sterilization of a potentially pathogenic biomass in a single, one-step process (see Figure 2).

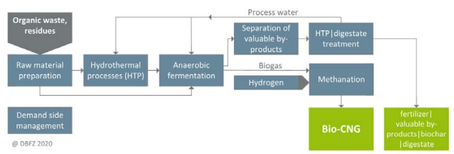


Figure 1: Main process steps in the plant concept.

Materials and Methods

As a first step an SOP for HTL experiments will be established. For this purpose, bomb-type batch reactors will be procured. Experiments with wet biomass and catalysts can be conducted in an oven. After cooling the reactor, the products are separated and analyzed via elemental analysis, GC-MS, HPLC, TKN, ICP and TGA. This will enable us to set up mass and energy balances and investigate the influence of process parameters and feedstock composition on the products. Based on this data, suitable reaction conditions can be determined to achieve optimal fuel properties and nutrient separation.

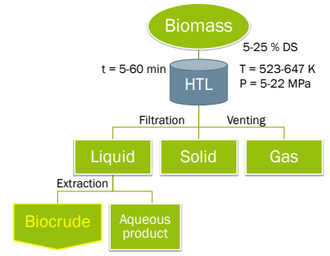


Figure 2: HTL process and downstreaming.

Outlook

Following these screenings, this thesis aims to address the following points:

- Influence of feedstock, temperature, time and catalyst on product distribution and composition
- Optimizing biocrude yield
- Kinetic modelling and prediction of optimal reaction conditions
- Investigate the exploitation of process water

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Straße 116 | 04347 Leipzig | www.dbfz.de
Ansprechpartner: Christian Klüpfel
E-Mail: christian.kluepfel@dbfz.de | Telefon: +49 (0)341 2434-436

PILOT SBG

Federal Ministry of Transport and Digital Infrastructure

18th September, 2020 | 13:30 - 14:45

Niklas Stobernack, Technische Hochschule Köln

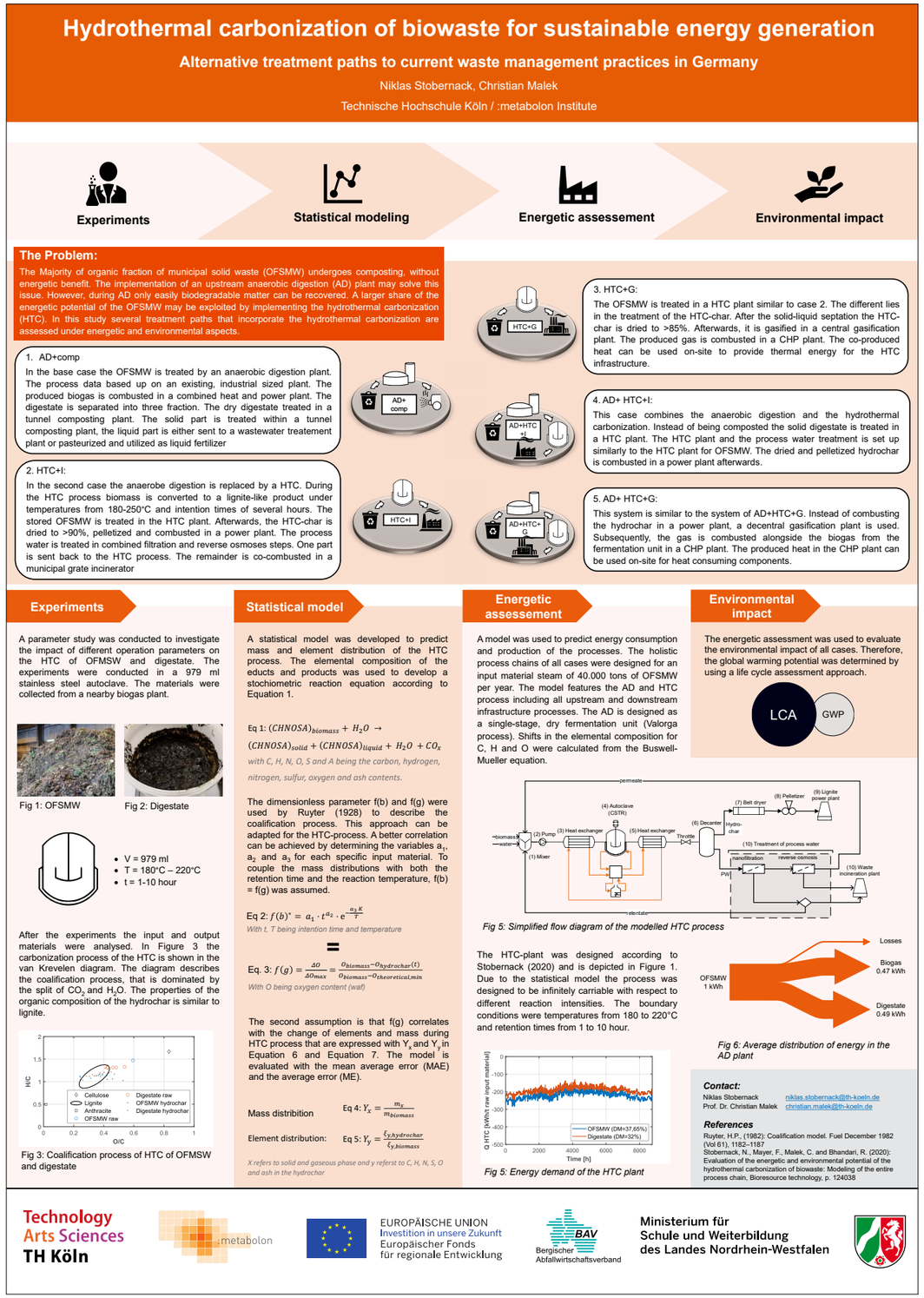
Hydrothermal carbonization of OFSMW for sustainable energy generation – Alternative treatment paths to current waste management practices in German

Niklas Stobernack, Christian Malek
University of Siegen
E-Mail: **niklas.stobernack@th-koeln.de**

Due to the conversion process from fossil to a renewable energy supply the importance of biomass as a base load energy source increase. A potential input material is the source segregated organic fraction of municipal solid waste (OFSMW). Within the German scope a majority of OFSMW undergoes composting, without energy recovery. The implementation of an upstream anaerobic digestion plant may resolve this issue. As energy can only be recovered from easily biodegradable matter, a larger share of the energetic potential stays unused. An alternative process to treat OFSMW is a hydrothermal carbonization (HTC). HTC can be used to convert OFSMW in a coal-like intermediate product, which can be further used for an energetic exploitation. In this study different process chains for the treatment of OFSMW were investigated and compared with anaerobic digestion followed by composting. The analysis aims to find an apt application of the HTC process, to increase the overall energetic yield. Ideally synergetic effects are taken advantage of.

- AD+comp: base case, OFSMW is treated in an anaerobic digestion plant and the digestate is composted.
- HTC+I: OFSMW is carbonized in an HTC unit and the solid product is co-combusted in a lignite power plant.
- HTC+G: similar to 2, but HTC-char is gasified decentral.
- AD+HTC+I: OFSMW is fermented similar to 1. Digestate is carbonized in HTC and treaded in lignite power plant afterwards.
- AD+HTC+G: similar to 4, but HTC-char is gasified decentral

Therefore, a model was created to solve mass and energy balances for the different treatment paths. The mass distribution of the HTC model was based on a statistical model that was created with experimental data from previous experiments. In this concept process chains are holistically reflected. The total input of energy is assumed to be 1 kWh and contrasted against the total exergy output. Thus, the different process chains are comparable. Treatment options featuring an HTC process were in general found to recover a higher proportion of the input energy. Due to limited heat recovery, however, central solutions require a higher demand of external heat Process chains with combination of HTC and AD could be operated nearly self-sufficient. Especially, in the treatment path (5) heat from the digestion process and gasification can be recovered for the process. The results of the energy balances form the basis for a comparison of the process chains under an ecological view. A second abstract from our team was submitted for this purpose.



18th September, 2020 | 13:30 - 14:45

Daniil Salionov, Paul-Scherer-Institut

Revealing the chemical composition of bio-oils derived from Spirulina, Miscanthus, and sewage sludge-based biomass by softionization high-resolution mass spectrometry.

Daniil Salinov, Dr. Saša Bjelic
L'Ecole polytechnique fédérale de Lausanne
Route Cantonale
1015 Lausanne
Phone: +41 (0) 563102103
E-Mail: **daniil.salionov@psi.ch**

The production of bio-oils is becoming increasingly important due to the need to decrease environmental contamination, dependence on fossil fuels, and for its potential to generate economic value from waste residues. Hydrothermal liquefaction is a thermal decomposition process utilized for the conversion of the wet biomass into bio-fuels with the potential for further upgrading into a fuel suitable for road transportation and aviation. The possibility of biomass to bio-fuel conversion has been shown for the lignocellulosic material, algae, and municipal wastes Chemical characterization of the crude bio-oil is crucial for the further upgrading steps to improve its properties and thus converting into a valuable energy source. Efficient and complete analysis of the bio-oil constituents could be achieved by high-resolution mass spectrometry (HRMS) with the use of a combination of soft ionization methods such as electrospray (ESI) and atmospheric pressure chemical ionization (APCI). Due to the high resolution and mass accuracy, the unique elemental composition can be generated for each mass spectrometric peak. Also, the implementation of different ionization sources allows expanding the observed chemical space as each ionization method has its biases towards the molecular weight (MW), polarity, and physicochemical properties of the analytes and thus providing a partial description of the whole sample. In this study, within HyFlexFuel project, three bio-crude samples derived from the conversion of Spirulina, Miscanthus, and sewage sludge were analyzed by means of liquid- chromatography – HRMS with ESI and APCI ionization methods. Visualization of the chemical composition was performed with heteroatom class distributions, Van Krevelen diagrams, and 2D distributions of the double bond equivalent values (DBE) versus MW, calculated by the kernel density function. It was found that the ESI is more specific in the ionization of the molecules with a lower DBE and MW and higher heteroatom content rather than APCI. The additional exploration of the trends in the data was performed by principal component analysis (PCA). It was found that the samples were separated among PC1 and PC2 axis according to the biomass type and ionization source used, respectively. The *K*-Means algorithm was applied to the PCA loadings to separate the molecules according to their contribution to the principal components. The findings showed that the samples were mainly separated on the PC1 according to the oxygen to carbon and nitrogen to carbon ratios. At the same time, the PC2 is primarily affected by the DBE values and oxygen content in the molecule. These findings suggest that the ionization of the molecule by the APCI source depends on its saturation level and oxygen content, while for the ESI source, the most important feature was found to be the heteroatom composition. The further analysis of the bio-crudes by APPI source will generate a complete picture of their composition.

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

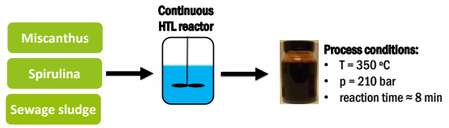
Revealing the chemical composition of bio-oils derived from Spirulina, Miscanthus, and sewage sludge based biomass by soft-ionization high-resolution mass spectrometry

Salionov Daniil[1,2], Saša Bjelić[1*]

INTRODUCTION

Hydrothermal liquefaction (HTL) is a thermal depolymerization process used for the conversion of the wet biomass into bio-fuels with the potential for the further upgrading into a diesel-like equivalent fuel for transportation and aviation. Efficient and complete analysis of the bio-oil constituents could be achieved by high-resolution mass spectrometry (HRMS) with the use of a combination of soft ionization methods such as electrospray (ESI) and atmospheric pressure chemical ionization (APCI).
Three bio-crude samples derived from HTL of Spirulina, Miscanthus, and sewage sludge were analyzed by means of liquid-chromatography (LC) – HRMS with ESI and APCI ionization methods. Visualization of the chemical composition was performed with heteroatom class distributions, Van Krevelen diagrams, and 2D distributions of the double bond equivalent values (DBE) versus molecular weights (MW), calculated with the use of kernel density function. For the mining of hidden trends in the data, the principal component analysis (PCA) was utilized.

MATERIALS AND METHODS



LC-HRMS setup: Thermo Scientific Q-Extractive hybrid quadrupole-Orbitrap mass spectrometer coupled to Thermo Scientific UltiMate 3000 UHPLC system. Mobile phase A: 0.2% (v/v) formic acid in 1%AcN/1%MeOH/Water, B: MeOH. Column - Accucore RP-MS (150 mm x 2.1 mm, particle size 2.6 µm). Gradient: 1-99%B in 6 min, flow 0.7 mL/min.

RESULTS

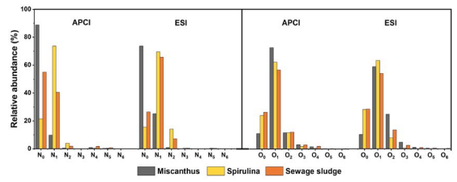


Figure 1: relative abundance of different heteroatom classes obtained using ESI and APCI ionization sources of the Miscanthus, Spirulina, and sewage sludge derived bio-crudes.

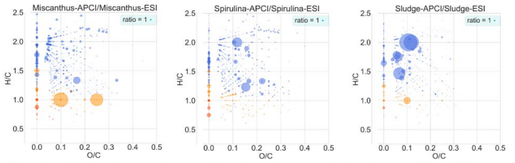


Figure 2: relative Van Krevelen diagrams of the bio-crude samples obtained from the ESI and APCI ionization of Miscanthus, Spirulina, and sewage sludge samples. The size and the color of the dots correspond to the relative abundance of the compound and its level of unsaturation. Color code: blue - aliphatic, orange - aromatic, and red - condensed aromatic species.

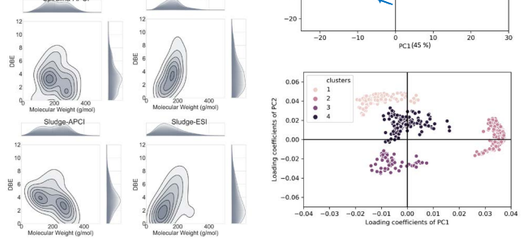


Figure 3: Kernel density plots of the molecular weights and double bond equivalent values (DBE) of the compounds observed in bio-crudes from Miscanthus, Spirulina, and sewage sludge with the use of APCI (left) and ESI (right) source.

Figure 4: The scatter plot of the PCA components (top) and loadings (bottom). The color and marker type on the PCA plot correspond to the biomass type and ionization source used. The arrows annotate the spread and coincidence of the sample compositions obtained using different ionization sources.

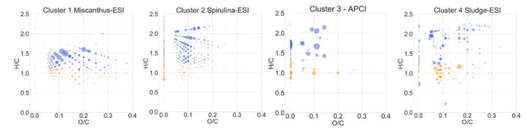


Figure 5: Van Krevelen diagrams of the clusters derived from PCA analysis. Each cluster corresponds to the unique chemical composition of each bio-crude and ionization source combination.

ACKNOWLEDGMENTS

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 764734. Bio-crude samples were produced at Aarhus University according to the procedure described in K. Anastasakis, P. Biller, R. B. Madsen, M. Glasius, and I. Johannsen, "Continuous hydrothermal liquefaction of biomass in a novel pilot plant with heat recovery and hydraulic oscillation," Energies, vol. 11, no. 10, p. 2695, 2018. We thank Prof. Christian Ludwig for valuable discussions.

CONCLUSION

- ESI source is more specific in the ionization of the molecules with a lower DBE and MW and higher heteroatom content than APCI
- Results of the PCA analysis showed that the ESI source is more sensitive to the biomass origin than APCI
- The evaluation of the molecular features of each biomass/source type (clusters 1 to 4) is now under consideration.

***Paul Scherrer Institut: Saša Bjelić|** E-Mail: sasa.bjelic@psi.ch | Telefon: +41 56 310 56 15
[1] Paul Scherrer Institut, Energy and Environment Research Division, Bioenergy and Catalysis Laboratory, Catalytic Process Engineering Group, 5232, Villigen PSI, Switzerland
[2] École polytechnique fédérale de Lausanne, ENAC IIE GR-LUD, 1015, Lausanne, Switzerland

18th September, 2020 | 13:30 - 14:45

Marius Drexler, Karlsruhe Institute of Technology, Institute of Catalysis Research and Technology

Production of oxymethylene ether as renewable liquid fuel in an anhydrous process

Marius Drexler, Ulrich Arnold, Philipp Haltenort, Jörg Sauer
Karlsruhe Institute of Technology, Institute of Catalysis Research and Technology
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen
E-Mail: **marius.drexler@kit.edu**

Oxymethylene ether (OME) are currently thoroughly investigated as an alternative liquid fuel. Due to the fuel properties of OME3-5 being similar to diesel fuel they have the potential to be employed with arguable effort regarding the compatibility to existing infrastructure [1]. Furthermore, due to the absence of carbon-carbon bonds in their molecular structure formation of pollutants can be effectively suppressed in the combustion process [2,3].

OME can be synthesized from methanol or derivatives thereof and a source of formaldehyde. In a process based on renewables, green methanol and formaldehyde can be synthesized from synthesis gas e.g. via biomass gasification [4]. A promising approach is the production of OME in a water free process, employing dimethyl ether (DME) and a source of dry formaldehyde like trioxane. By elimination of water in the synthesis step, formation of side products can be minimized and higher yields are viable [5]. Recent studies show, that synthesis of OME from DME and trioxane employing acidic catalysts such as zeolite H-BEA-25 in a liquid phase reaction is feasible [6].

To further investigate the subject, screening experiments with different catalysts in an autoclave setup have been conducted. The setup consists of a stainless steel autoclave and a manual dosing unit for liquid DME. The reaction temperature and stirring rate are controlled by a magnetic stirrer unit. The product phase is analyzed by GC-FID. Aside the comparison of activities of different catalyst systems, kinetic studies have been conducted by variation of reaction temperature and time. Results show promising new catalyst candidates as well as a time- and temperaturedependent shift in the product spectrum. This indicates the opportunity to increase the yield of OME3-5 by kinetic control. Since the results of the batch experiments are very promising, future investigations aim to transfer the process to a continuous setup for a wider range of process parameters.

References:
[1.] L. Lautenschütz, D. Oestreich, P. Seidenspinner, U. Arnold, E. Dinjus, J. Sauer, Fuel 2016, 173, 129 – 137. DOI: https://doi.org/10.1016/j.fuel.2016.01.060
[2.] D. Oestreich, L. Lautenschütz, U. Arnold, J. Sauer, Fuel 2018, 214, 39 – 44. DOI: https://doi.org/10.1016/j.fuel.2017.10.116
[3.] D. Pélerin, K. Gaukel, M. Härtl, E. Jacob, G. Wachtmeister, Fuel 2020, 259, 116231. DOI: https://doi.org/10.1016/j.fuel.2019.116231
[4.] X. Zhang, A. O. Oyedun, A. Kumar, D. Oestreich, U. Arnold, J. Sauer, Biomass and Bioenergy 2016, 90, 7 – 14. DOI: https://doi.org/10.1016/j.biombioe.2016.03.032
[5.] J. Burger, E. Ströfer, H. Hasse, Ind. Eng. Chem. Res. 2012, 51 (39), 12751 – 12761. DOI: https://doi.org/10.1021/ie301490q
[6.] P. Haltenort, K. Hackbarth, D. Oestreich, L. Lautenschütz,U. Arnold, J. Sauer, Catalysis Communications 2018, 109, 80 – 84. DOI: https://doi.org/10.1016/j.catcom.2018.02.013L.Lautenschütz

BIOENERGY DOC2020 | 3RD DOCTORAL COLLOQUIUM BIOENERGY
17TH/18TH SEPTEMBER 2020, LEIPZIG

Production of oxymethylene ether (OME) as renewable liquid fuel in an anhydrous process

Marius Drexler, Ulrich Arnold, Philipp Haltenort, Jörg Sauer

Introduction & Motivation

Scope: efficient synthesis of Oxymethylene ethers (OME_n) as a synthetic fuel

Motivation:
- No soot formation during combustion
- Reduction of NO_x emission feasible
- Fuel properties similar to diesel (OME_{3-5})
- Sustainable synthesis from renewable sources via syngas platform

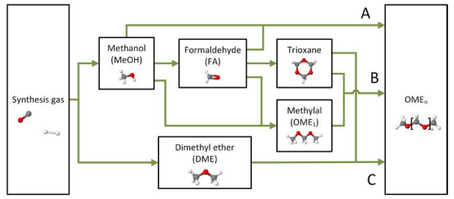


Figure 1: Possible production pathways for OME_n based on synthesis gas

This work:
- Focus on the synthesis of OME_n in an anhydrous process (depicted as route C in Figure 1)
- Reaction of DME and trioxane in the presence of an acidic catalyst

Experimental Work

- Global reaction:

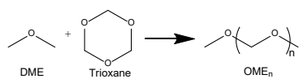


Figure 2: Reaction equation for OME_n synthesis from DME and trioxane

Figure 3: Autoclave setup for batch experiments

- Autoclave setup for batch experiments
- Catalyst preparation by cation exchange procedures
- Formation of methyl formate as byproduct
- Screening of catalysts as well as reaction conditions

- Highly active zeolite catalyst H-BEA-25 known from previous work as reference case
- Use of Montmorillonite K10 as a large pore parent material with high accessible surface area
- Customized acidic properties by intercalation of different cations into the original K10 material

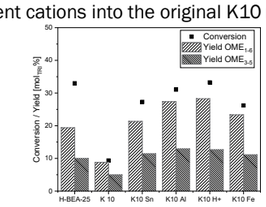


Figure 4: Screening experiments: n_{TRI}/n_{DME} = 0.25, 2.6 wt%$_R$ Catalyst, 50 wt% Dodecane, 500 rpm, 6 h, 80° C liquid product phase

- Significant increase of the catalytic activity for the cation exchanged material
- Similar conversion rates with higher selectivities than the reference catalyst

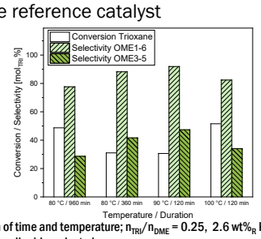


Figure 5: Variation of time and temperature; n_{TRI}/n_{DME} = 0.25, 2.6 wt%$_R$ K10 Al, 50 wt% Dodecane, 500 rpm, liquid product phase

- Variation of time and temperature lead to shift of composition of OME_n fraction
- Best results achieved at higher temperatures and lower residence time, up to 19.5 wt% OME_{1-6} in the liquid product phase

Acknowledgement

This work is embedded in the NAMOSYN project for sustainable mobility with synthetic fuels and has received funding from the German Federal Ministry of Education and Research (BMBF) under Grant No. 03SF0566K0

SPONSORED BY THE
Federal Ministry of Education and Research
Projektträger Jülich Forschungszentrum Jülich

Karlsruhe Institute of Technology (KIT) | Kaiserstraße 12 | 76131 Karlsruhe | www.kit.edu
Contact: Marius Drexler | E-Mail: marius.drexler@kit.edu

Karlsruhe Institute of Technology (KIT), Institute of Catalysis Research and Technology (IKFT)
Hermann-von-Helmholtz-Platz 1
76344 Eggenstein-Leopoldshafen

NAMOSYN Nachhaltige Mobilität durch synthetische Kraftstoffe

ORAL PRESENTATIONS

SESSION 5
BIOREFINERIES

3RD DOCTORAL COLLOQUIUM BIOENERGY

18th September, 2020 | 14:45

Robert Pujan, Deutsches Biomasseforschungszentrum

ProMo – A Tool for the Systematic Modelling of Biorefinery Processes

Robert Pujan, Heinz A. Preisig
NTNU Norges Teknisk-Naturvitenskapelige Universitet
Høgskoleringen 5
NO-7491 Trondheim
Phone: +49 (0)341 2434-452
E-Mail: **robert.pujan@dbfz.de**

Research and development in modern biorefinery concepts require the combination of multiple disciplines such as physics, biology, chemistry, and engineering.

Correspondingly, one has to utilise the same large pool of interdisciplinary expertise when designing biorefinery models. Thus, assembling the biorefinery-relevant expertise of various scientific roots in an ontology that is a collection of fundamental principles, relations, and definitions, substantially aids process modelling, enables rapid design, and minimises modeller-caused errors. The modelling suite ProMo, currently in development at the NTNU, is therefore intended to be equipped with a biorefinery ontology that combines physics to describe the plant‘s physical structure, process control, biological and chemical conversion processes, economical calculations, and material properties. This work is done in collaboration with the DBFZ. The ProMo suite is entirely based on ontologies, which are used to represent the various knowledge domains and allows for their seamless combination. The ProMo suite requires a group of specialists to generate and maintain the underlying ontologies but releases the typical process modeller from implementing the essential behaviour representation since the implemented ontology frees the modeller from equation writing. Instead, the modeller‘s focus is on defining a problem-appropriate process structure as a topology. Based on this process topology, ProMo automatically pulls the required compiled equations and relations from the ontology, and ProMo‘s task factory generates with the help of a graph-based reasoner executable program code for simulation runs.
The study introduces this systematic modelling approach by applying it to a simple biorefinery con2 cept. This exemplary process is utilised to demonstrate ProMo‘s methodology and to discuss its realisation in the modelling suite. The presentation also reveals that ProMo will be applicable in multi-scale domains and for both, preliminary concept assessments before experimental runs as well as detailed process models fitted to experimental data.

18th September, 2020 | 15:10

Jakob Köchermann, Deutsches Biomasseforschungszentrum

Path of process development for hydrothermal production of furfural from biomass and biomass hydrolysates

Jakob Köchermann
TU Berlin
Straße des 17. Juni 135
10623 Berlin
Phone: +49 (0)341 2434-359
E-Mail: **jakob.koechermann@dbfz.de**

Furfural is a versatile and biorenewable precursor, in particular for the production of fuels but also for resins, solvents or plastics and is therefore called a platform chemical. Due to the requirement of non-fossil based chemicals, furfural has been widely discussed over the last decade. For the production, hemicellulose-rich biogenic residues such as oat hulls, bagasse or corn cobs are used. However, commercial plants have low furfural yields (< 11% based on the dry initial weight of the biomass) and require huge amounts of sulfuric acid, which afterwards leads to acidified waste water and contaminated, unconverted biomass (cellulose, lignin). From this point of view, more efficient and sustainable processes must be developed.

Hydrothermal processes represent a promising alternative. In these processes biomass is converted in hot compressed water to furfural. The advantage of this approach lies in the reduction of the use of mineral acids. However, the formation of insoluble by-products, also called humins, is disadvantageous. In this contribution, three different hydrothermal process approaches should be presented. First, a simple hydrothermal conversion in a continuous process, followed by a discontinuous reaction with the aid of ethanol as co-solvent and finally a hydrothermal reactive distillation (HRD).

For all hydrothermal approaches, a hydrolysate rich in hemicellulose, made from an organosolv process, was available. For simple hydrothermal conversion without the use of any auxiliaries good conversion rate in combination with a moderate furfural selectivity could be observed (Köchermann et al. 2018). By using ethanol as a co-solvent, the yield could be significantly increased and the formation of humins reduced (Köchermann et al. 2019). However, this result could only be observed when using xylose as a model substance. No difference could be found with real hydrolysates. Best performance could be noticed for HRD. A high furfural yield and purity, without humins, was achieved in the product solution (Köchermann 2020).

The contribution gives a summary of the past three years of process development. The path from the initial challenge to the closing solution should be presented.

References:
Köchermann, Jakob (2020): Production of Furfural and Levulinic Acid in a Two-Stage Hydrothermal Conversion Process as Precursor for GVL. 13th International Conference on Bio- based Materials. nova-Institut GmbH. Online Conference, 14.05.2020.
Köchermann, Jakob; Schreiber, Janine; Klemm, Marco (2019): Conversion of d-Xylose and Hemicellulose in Water/Ethanol Mixtures. In: ACS Sustainable Chem. Eng. 7 (14), S. 12323–12330.
Köchermann, Jakob; Mühlenberg, Jana; Klemm, Marco (2018): Kinetics of Hydrothermal Furfural Production from Organosolv Hemicellulose and D-Xylose. In: Ind. Eng. Chem. Res. 57 (43), S.14417–14427.

18th September, 2020 | 15:35

Leonard Moser, Bauhaus Luftfahrt e.V.

A comprehensive model for liquid hydrocarbon fuel production via hydrothermal liquefaction – combining a complex reaction network with a simulation of a process chain

Leonard Moser, Christina Penke, Valentin Batteiger
Bauhaus Luftfahrt e.V.
Phone: +49 (0)1525 6112216
E-Mail: **leonard.moser@bauhaus-luftfahrt.net**

Hydrothermal liquefaction (HTL) is a promising technology option to convert a variety of organic feedstocks into biofuels. Besides experimental work, modeling of HTL processes and process chains is an important research field, especially in the context of life cycle analysis (LCA), techno-economic assessment (TEA) and the projection of full-scale plant performance based on pilot plant results The field of HTL process models can be differentiated by their characteristics, two of them being the use of a reaction network and the consideration of a process chain connected to the HTL process. Previous studies of the HTL process with a reaction network are mainly based on HTL batch experiments. Most of the studies use a small number of model compounds and do not consider the process chain of the HTL process. The most prominent system analyses of continuous HTL processes and process chains were performed by the Pacific Northwest National Laboratory. However, no actual reactions are considered. The unique and valuable features of this model are the complexity of the reaction network and the modelling of a continuous process chain, including the treatment of HTL by-products. The HTL model was set up in Aspen Plus and conducted for the feedstocks spirulina, miscanthus and sewage sludge. Based on the composition of biomass, five different types of components (lipids, proteins, carbohydrates, lignin, ash) are distinguished. Except for ash, the components undergo hydrolysis during HTL conversion, which is already assumed in this model. The different feedstocks are described by 25 model components, which are subsequently reacted in an HTL reactor. The resulting biocrude is further upgraded in a hydrotreating unit. It is of great importance to investigate the use of all by-products of the HTL process chain to achieve the generation of competitive biofuels with regard to price and environmental impact. By-products are the aqueous phase and the HTL solids. Catalytic hydrothermal gasification (cHTG), as well as anaerobic digestion (AD) are considered to process the aqueous phase. Subsequently, the cHTG/AD gas is combusted for heat and power generation. Struvite, a fertilizer product, can be recovered from HTL solids and a brine from cHTG of HTL process waters. The main process parameters correspond to the process conditions of experiments from the EU funded HyFlexFuel project. The results of the model, which include elemental analysis, simulated distillation, mass and energy balances as well as process efficiencies, are validated by experimental results obtained in the HyFlexFuel project. To the best of our knowledge, this is the first model that combines a complex reaction network with the investigation of the HTL process chain. The model will serve as basis for a subsequently conducted LCA and TEA.

18th September, 2020 | 16:00

Lilli Sophia Röder, Deutsches Biomasseforschungszentrum

Flexibility options for demand side management in biorefineries

Lilli Sophia Röder, Arne Gröngröft
Deutsches Biomasseforschungszentrum
Torgauer Str. 116
04347 Leipzig
Phone: +49 (0)341 2434-424
E-Mail: **lilli.sophia.roeder@dbfz.de**

The ongoing expansion of renewable energies and the resulting fluctuating electricity production create new challenges for the transmission system. There are various ways to counteract these fluctuations. In addition to storage options and flexible power plants, the temporal adjustment of the electricity load, the so-called demand side management (DSM), is currently gaining focus and importance. This load-side control system changes the electricity consumption in such a way that the energy requirements can flexibly be adapted to the current available electricity capacities and thus match the electricity peaks produced by renewable energies.

As part of the PILOT-SBG project of the biorefineries department at the German Biomass Research Centre (DBFZ), the implementation of a DSM in biorefineries and the effects it imposes are to be tested. The aim is to achieve high exploitation of electricity generation from volatile renewable energy sources in the biofuel production step, thereby avoiding the use of fossil fuels and reducing greenhouse gases. The DSM concept is to be designed and tested using the pilot SBG system as an example but should be transferable to other biorefineries.

The presentation will show the first stage of the current DSM study. This step consists in creating a digital replica and simulation of the entire biorefinery. This simulation shall be used to determine the time course of the energy consumption of system components. Measurements on the process steps of the pilot plant are necessary to validate and adapt the simulation. The possibilities and limits of such a simulation and the resulting representation of the temporal energy recording are to be examined and demonstrated. The results will later allow an assessment of the potential of different parts of the system regarding the temporal and quantitative adaptability of the electricity load. Further study is intended to clarify whether load management not only relieves an excessive load on the distribution network but also represents an economic incentive for the operator. In addition, it is important to examine whether the greenhouse gas balance of the entire plant improves without causing significant quality or output losses in production.

ORAL PRESENTATIONS

SESSION 6
THERMOCHEMICAL CONVERSION

3RD DOCTORAL COLLOQUIUM BIOENERGY

18th September, 2020 | 14:45

Johannes Lukas, Friedrich-Alexander-University Erlangen-Nürnberg

Data analysis and CFD simulations based on live data of a biomass cogeneration plant for emission prediction and reduction

Johannes Lukas, T. Plankenbühler, D. Müller, J. Karl
Friedrich-Alexander-University Erlangen-Nürnberg
Fürther Str. 244f
90429 Nürnberg
Phone: +49 (0)91153019033
E-Mail: **johannes.lukas@fau.de**

The combustion of biomass in a fluidized bed is a well-established concept renowned for its highly efficient and flexible combustion properties for a wide range of solid fuels. However, fluctuating fuel quality concerning the composition and size of the solid fuel pieces leads to changes in the emission characteristics and leave room for optimization. Aim of our work is an on-line emission control system based on simulations that describe the formation of gaseous emissions in a biomass fluidized bed furnace and different kinds of data analysis using live data of a biomass cogeneration plant. This live data contains all the information needed for a significant reduction of NOx – emission using CFD-Simulations and data analysis methods.

Exploratory data analysis

Different types of exploratory data analysis (EDA) of the biomass cogeneration plant are suitable to detect correlations and reveal potential for optimization through machine learning algorithms. The classification of the NOx time series in various groups and the examination of influences of different process data by principle component analysis (PCA) can be visualized. Through dimensionality reduction, relevant variables for machine- learning algorithms that can be used for the classification of e.g. distinct NOx emission levels are determined. In addition, cross correlations as shown exemplarily for CO and NOx are useful to detect and quantify correlations and time dependences in the data.

CFD simulations in Barracuda

In order to develop a spatial on-line emission prediction model, we carried out simulations in the geometry of the power plant combustion chamber and in a smaller lab-scale plant with the CFD-software Barracuda. We applied temperatures, flows and concentrations of different load cases of the cogeneration plant as input parameters for the simulations of the industrial-scale plant. In order to expand the prediction range of the experience based machine-learning algorithm, data for different fuel properties of e.g. new fuels can be created by changing the input parameters of the simulations and use the results to expand the training set.

Fuel quality monitoring

Changing fuel quality and have great impact on emission characteristics but are not captured precisely during the operation of the biomass cogeneration plant Schongau. Therefore, we install a camera system that provides insight of the size distribution and changes in fuel properties. This conference contribution presents data analysis and simulations based on a biomass cogeneration plant´s live data as preparation for the implementation of an experience-based control system. We achieved a better understanding of the interrelationships determining the emission characteristics of the plant through both the simulations and the data analysis. Through the installation of a fuel monitoring system with a camera in the fuel feed, changing fuel properties can be detected.

18th September, 2020 | 15:10

Katharina Fürsatz, BEST – Bioenergy and Sustainable Technologies GmbH

In-situ activation of K-feldspar by fuel ash layers for DFB steam gasification

Katharina Fürsatz, Matthias Kuba, Nils Skoglund, Hermann Hofbauer
TU Wien
Getreidemarkt 9/166
1060 Vienna
Phone: +43 5 02378-9365
E-Mail: **katharina.fuersatz@best-research.eu**

In dual fluidized bed (DFB) steam gasification the bed material is used to transport heat from the combustion to the gasification reactor, but also to act as a catalyst for gasification reactions, e.g. the water-gas-shift (WGS) reaction and tar reforming. Interactions between fuel ash and bed material lead to layers forming on the bed material, which further increase the catalytic activity of the bed material. This increase in catalytic activity was also observed for olivine, which is currently used as bed material in commercial DFB steam gasification plants. However, traces of heavy metals in olivine make the disposal of bottom ash more complex and costly. The search for a heavy metal-free alternative is, therefore, of major interest. As a widely available mineral, K- feldspar was chosen for studies for its suitability as replacement for olivine, with special focus given to its catalytic activity and activation by fuel ash layers. Gasification and combustion experiments were performed with K-feldspar as bed material. A wide variety of ash-rich fuels (i.e. bark, chicken manure) were used to study the influence of ash on the layer formation and catalytic activation of the bed material. It was possible to observe the positive impact of fuel ash during the gasification with an ash-rich bark-straw-chicken manure mixture. The gas composition improved considerably during the operation time of around 2.5 hours. The increase in hydrogen is caused by the increasing amount of ash in the system as well as initial layer formation on the bed material. To further study the influence of fuel ash layers on the catalytic activity, several bed material samples from fluidized bed combustion of ash- rich fuels were studied regarding their catalytic activity towards the WGS reaction. Activation of the K-feldspar bed material was observable for all fuels. While the unused K-feldspar reached 2 % of the achievable hydrogen yield according to the WGS equilibrium, it was possible to reach up to 49 % for the most active samples. Scanning electron microscopy imaging showed layers forming on the K-feldspar bed materials, further supporting the influence of fuel ash layers on the catalytic activity. Energy dispersive X-ray spectroscopy analysis showed that the layers forming are rich in calcium, magnesium and phosphorus.

18th September, 2020 | 15:35

Maximilian Weitzer, Friedrich-Alexander-University Erlangen-Nürnberg

Development of a pellet boiler for micro-CHP with an organic Rankine cycle

Maximilian Weitzer, Dominik Müller, Jürgen Karl
Friedrich-Alexander-University Erlangen-Nürnberg
Fürther Str. 244f
90429 Nürnberg
Phone: +49 (0)91153029022
E-Mail: **maximilian.weitzer@fau.de**

Organic Rankine cycles (ORC) are an established technology for generating electricity from low-temperature heat sources in a range from a few kilowatts to several megawatts. At low temperatures and power ranges, organic working fluids have advantageous properties compared to water. Originally, ORCs were used for power generation from geothermal energy. Since then, researchers successfully demonstrated the application of ORCs in combination with industrial waste heat and solar energy. Especially for combined heat and power (CHP) from biomass in a small to medium scale and as bottoming cycles for gas turbines, organic Rankine cycles have become a well-established technology.

At the Chair of Energy Process Engineering at the University of Erlangen-Nürnberg a new approach is currently investigated in order to combine an ORC with a pellet boiler for micro-CHP. The main challenges of micro-CHP systems are generally high specific investment costs and low electrical efficiencies. The key for an efficient ORC process is the heat supply on a high temperature level. The new approach tackles this issue by integrating a novel internal heat exchanger into the combustion chamber of the boiler. While standard pellet boilers only allow water temperatures below 100 °C, this internal heat exchanger can heat up pressurized water to 120 °C. The higher temperature leads to an increased electrical efficiency of the ORC.

Additionally, an exhaust gas recirculation (EGR) is integrated into the pellet boiler. The EGR enables a reduced air-to-fuel ratio and avoids the formation of hot spots and ash melting on the grate. The lab-tests so far have shown that the EGR leads to a significant reduction of the gaseous emissions CO and NOx as well as particulate matter. Moreover, the integration of the EGR increased the combustion efficiency of the pellet boiler due to the reduced air-to-fuel ratio. Further tests will be conducted with and without EGR at full and part load in order to find an optimal load-depending control strategy for reduced emissions and high efficiencies.

The development of the pellet boiler for micro-CHP with an ORC is part of the EU-project SolBio-Rev. The overall concept of SolBio-Rev is based on an innovative, reversible heat pump/ORC process that can supply buildings with heat, cold and electricity throughout the whole year. Depending on season and weather, solar energy and biomass are used as renewable energy sources for the reversible ORC system. In the last year of the four-year project two pilot plants will be installed in Nürnberg and Athens respectively. These pilot plants will be a small-scale prototype of the SolBio-Rev system and will demonstrate the advantages of the system in a field test.

18th September, 2020 | 16:00

Michael Eßl, BEST – Bioenergy and Sustainable Technologies GmbH

Numerical simulation of fuel nitrogen conversion and NOx emissions in biomass boilers with advanced air staging technology

Michael Eßl, Kai Schulze, Robert Scharler
Graz University of Technology
Inffeldgasse
8010 Graz
E-Mail: **michael.essl@best-research.eu**

The increased biomass utilization leads to the need of an efficient and flexible usage of available sources. Therefore, it is necessary to combust low-cost biogenic residues, which inherently have higher nitrogen contents that lead to increased NOx emissions. In order to tackle this issue a new combustion technology with double air staging and flue gas recirculation is under development. The technology also features an increased fuel bed height and very low oxygen concentrations in the fuel bed to reduce fuel bed temperatures. This work focuses on the CFD simulation of the formation and reduction of NOx emissions of in a small scale boiler (35 kWth). Compared to previously applied models, major modification concerning the heat and mass transfer in the fuel bed as well as the subsequent conversion in the freeboard were made. The fuel bed is modelled via representative fuel particles with a Lagrangian approach and a thermally thick particle model considering intra-particle gradients. Due to the increased fuel bed height and the relatively low oxygen concentration the formation and cracking of tars has to be considered in the simulation. This heavily influences the formation and reduction of NOx and its precursors. The fuel bound nitrogen is released via the particle model in the form of NO during char burnout and via a lumped tar species during pyrolysis. The cracking of the lumped tar species is modelled via two global gas phase reactions that releases the NOx precursors NH3 and HCN. The cracking reactions are added to a skeletal reaction mechanism with 28 species and 102 reactions that includes the fate of the N species. The simulation results are compared to experimental data from test runs with spruce wood chips and Miscanthus pellets as fuels. The comparison showed good agreement for the test runs with wood chips, where the temperature distribution inside the fuel bed and the released species above the fuel bed were predicted well. The test runs with Miscanthus showed a greater deviation between the measured and simulated values. For both fuels the NOx reduction that was experimentally observed in the secondary combustion zone could not be predicted with reasonable agreement. Therefore, it is necessary to further investigate the cracking of the tars and the subsequent formation of the NOx precursors. The presented work forms the basis for further improvements of the numerical models and subsequently the optimization of the new technology.

Organiser

DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH

Our mission

The DBFZ was founded in 2008 by the former Federal Ministry of Food, Agriculture and Consumer Protection (BMELV) with the aim of establishing a central research institution for all relevant fields of bioenergy research and to network the results of the very complex German research landscape in this sector. The scientific mission of the DBFZ is to provide comprehensive scientific support for the efficient integration of biomass as a valuable resource for sustainable energy supply within the framework of applied research. This mission includes technical, ecological, economic, social and energy management aspects along the entire process chain (from production, supply and use). The development of new processes, procedures and concepts is accompanied and supported by the DBFZ in close cooperation with industrial partners. At the same time, there is close networking with German public research in the agricultural, forestry and environmental sectors, as well as with European and international institutions. Based on this broad research background, the DBFZ also develops scientifically sound decision-making aids for policy makers.

Members of the Programme Committee

The programme committee is responsible for the content of the event and the professional supervision of the doctoral students.

It consists of the following representatives of various research institutions:

Prof. Dr. Daniela Thrän	Universität Leipzig, Professur Bioenergiesysteme DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH Helmholtz-Zentrum für Umweltforschung GmbH - UFZ
Prof. Dr. Jürgen Karl	FAU - Friedrich-Alexander-Universität Erlangen-Nürnberg, Lehrstuhl für Energieverfahrenstechnik
Prof. Dr. Enno Bahrs	Universität Hohenheim, Insitut für Landwirtschaftliche Betriebslehre
Prof. Dr. Nicolaus Dahmen	KIT - Karlsruher Institut für Technologie, Institut für Katalyseforschung und -technologie
Dr. Ludger Eltrop	Universität Stuttgart, Institut für Energiewirtschaft und Rationelle Energieanwendung
Prof. Dr. Matthias Gaderer	TUM - Technische Universität München, Professur für Regenerative Energiesysteme
Prof. Dr. Andrea Kruse	Universität Hohenheim, Institut für Agrartechnik
PD Dr. Kurt Möller	LTZ - Landwirtschaftliches Technologiezentrum Augustenberg, Referat Pflanzenbau
Prof. Dr. Michael Nelles	Universität Rostock, Professur für Abfall- und Stoffstromwirtschaft/ Deutsches Biomasseforschungszentrum gGmbH
Dr. Hans Oechsner	Universität Hohenheim, Landesanstalt für Agrartechnik und Bioenergie
Prof. Dr. Peter Georg Quicker	RWTH Aachen - Rheinisch Westfälische Technische Hochschule, Lehr- und Forschungsgebiet Technologie der Energierohstoffe
Dr. Kathrin Weber	SINTEF - Stiftelsen for industriell og teknisk forskning, Trondheim, Norway
Dr. Omar Hijazi	TUM - Technische Universität München, Lehrstuhl für Holzwissen-schaft

Logos

Members of the Programme Committee

Member of the Scientifc Advisory Board

The members of the Scientific Advisory Board provide the Programme Committee with expert support in specific questions and challenges. The advisory board consists of the following representatives:

Prof. Dr. Frank Baur	IZES gGmbH – Institut für ZukunfsEnergie- und Stoffstromsysteme an der Hochschule für Technik und Wirtschaft (HTW)
Dr. Günther Bochmann	Universität für Bodenkultur Wien, Institut für Umweltbiotechnologie
Dr. Ruth Delzeit	IfW – Insitut für Weltwirtschaft Kiel, Umwelt und natürliche Ressourcen
Prof. Dr. Christina Dornack	Technische Universität Dresden, Institut für Abfall- und Kreislaufwirtschaft
Prof. Dr. Magnus Fröhling	TUM – Technische Universität München, Professur Circular Economy
Prof. Dr. Markus Goldbrunner	Technische Hochschule Ingolstadt, Fakultät Maschinenbau
Adj. Prof. Dr. Walter Haslinger	Luleå University of Technology, Adjunct Professor of Energy Enginerring
Prof. Dr. Hauke Harms	Universität Leipzig / UFZ, Department Umweltmikrobiologie
Dr. Ingo Hartmann	DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Forschungsschwerpunkt Katalytische Emissionsminderung
Prof. Dr. Peter Heck	Umwelt-Campus Birkenfeld – Professur Forschunsbereich Umwelt-wirtschaft/ -recht
Prof. Dr. Hans-Martin Henning	Fraunhofer ISE – Fraunhofer Institut für Solare Energiesysteme, Professur für Solare Energiesysteme
Prof. Dr. Carsten Herbes	HfWU - Hochschule für Wirtschaft und Umwelt Nürtingen-Geislingen, Fakultät Betriebswirtschaft und Internationale Finanzen
Prof. Dr. Uwe Holzhammer	Technische Hochschule Ingolstadt, Energiesystemtechnik
Prof. Dr. Matthias Kraume	Technische Universität Berlin, Process Engineering
Dr. Lukas Kranzl	Technische Universität Wien, Heating/Cooling in integrated energy systems
Prof. Dr. Oliver Kröcher	Paul Scherer Institut, Bioenergy and Catalysis Laboratory
Dr. Peter Kornatz	DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Biochemische Konversion, Uni. Lecturer DI
Dr. Matthias Kuba	BEST - Unit Head - Fluidized Bed Technology at BEST – Bioenergy and Sustainable Technologies GmbH
Univ. Prof. Dr. Markus Lehner	Universität Leoben, Lehrstuhl für Verfahrenstechnik des industriellen Umweltschutzes
Dr. Volker Lenz	DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Thermochemische Konversion
Christian Leuchtweis	C.A.R.M.E.N. e.V, Centrales Agrar-Rohstoff Marketing- und Energie-Netzwerk e.V.
Prof. Dr. Achim Loewen	HAWK Göttingen, Fakultät Ressourcenmanagement
Prof. Dr. Christian Malek	Technische Hochschule Köln, Fakultät für Informatik und Ingenieur-wissenschaften
Dr. Franziska Müller-Langer	DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Biobasierte Produkte und Kraftstoffe
Prof. Dr. Andreas Ortwein	Hochschule Merseburg, Professur Prozessautomation/Gebäude-automation
Uni. Prof. Dr. Christoph Pfeifer	Universität für Bodenkultur Wien, Professur Institut für Verfahrens- und Energietechnik (IVET)
Prof. Dr. Dr. Thomas Rosenau	Universität für Bodenkultur Wien, Institut für Chemie nachwachsender Rohstoffe
Prof. Dr. Rüdiger Schaldach	Universität Kassel, Center for Environmental Systems Research
Prof. Dr. Hartmut Spliethoff	Technische Universität München, Professur Energiesysteme
Prof. Dr. Ulrich Schurr	Forschungszentrum Jülich, Pflanzenwissenschaften
Prof. Dr. Petra Schwizer-Ries	Hochschule Bochum, Fachbereich Elektrotechnik und Informatik
Prof. DI Dr. Horst Steinmüller	Johannes Kepler Universität Linz, Leiter der Abteilung für Energietechnik
Prof. Dr. Michael Sterner	Ostbayerische Technische Hochschule Regensburg, Energiespeicher und Energiesysteme

ANNEX

3RD DOCTORAL COLLOQUIUM BIOENERGY

Logos

Member of the Scientifc Advisory Board

BEST
Bioenergy and
Sustainable Technologies

BOKU
Universität für Bodenkultur Wien
University of Natural Resources
and Life Sciences, Vienna

TU berlin

Technische
Universität
München

C.A.R.M.E.N.

DBFZ

TECHNISCHE
UNIVERSITÄT
DRESDEN

UNIVERSITÄT
LEIPZIG

Hochschule für
Wirtschaft und Umwelt
Nürtingen-Geislingen

HoME
HOCHSCHULE
MERSEBURG
University of
Applied Sciences
FACHBEREICH
INGENIEUR- UND
NATURWISSEN-
SCHAFTEN

UFZ HELMHOLTZ
Zentrum für Umweltforschung

Fraunhofer
ISE

ifw KIEL INSTITUT FÜR
WELTWIRTSCHAFT

izes gGmbH
Institut für ZukunftsEnergie-
und Stoffstromsysteme

JÜLICH
FORSCHUNGSZENTRUM

MONTAN
UNIVERSITÄT
LEOBEN

PAUL SCHERRER INSTITUT
PSI

Technische Hochschule
Ingolstadt

Organizer:

DBFZ Deutsches Biomasseforschungszentrum
gemeinnützige GmbH
Torgauer Straße 116
04347 Leipzig
Phone: +49 (0)341 2434-112
Fax: +49 (0)341 2434-133
E-Mail: info@dbfz.de

www.dbfz.de

#DOC2020

WWW.DOC-BIOENERGY.DE