Mitteleuropäische Biomassekonferenz
Central European Biomass Conference
#CEBC2023

Tagungsband Proceedings

18. bis 20. Jänner 2023, Graz, Österreich

18th to 20th of January, 2023, Graz, Austria

7. Mitteleuropäische Biomassekonferenz CEBC2023

Eine Veranstaltung von:

Österreichischer Biomasse-Verband

Landwirtschaftskammer Steiermark

BEST Bioenergy and Sustainable Technologies

Exklusivpartner der Veranstaltung:

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Bundesministerium Land- und Forstwirtschaft, Regionen und Wasserwirtschaft

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7th Central European Biomass Conference CEBC2023

An event by:

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Landwirtschaftskammer Steiermark

BEST Bioenergy and Sustainable Technologies

Exclusive partners of the conference:

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Bioenergie – Lösungen für die Energie- und Umweltkrise

Der Österreichische Biomasse-Verband, die Landwirtschaftskammer Steiermark und die BEST - Bioenergy and Sustainable Technologies GmbH veranstalten in Kooperation mit der Messe Graz vom 18.–20. Jänner 2023 die **7. Mitteleuropäische Biomassekonferenz CEBC2023**. Die Welt befindet sich im Umbruch. Seit der vergangenen Konferenz vor drei Jahren hat uns die Corona-Pandemie überrollt, Russland hat einen Angriffskrieg auf die Ukraine begonnen, die Folgen des Klimawandels sind in ganz Europa zu spüren.

Die Zeit zu handeln ist jetzt!

Die Situation ist herausfordernd, aber wir werden und müssen sie gemeinsam bewältigen. Mit der Bioenergie haben wir in den vergangenen Jahrzehnten ein innovatives Zukunftsinstrument geschaffen. Gemeinsam mit den anderen erneuerbaren Energien Wind, Wasser, Sonne und Energiesparmaßnahmen trägt Bioenergie dazu bei, aus der fossilen Energieabhängigkeit auszusteigen. Voraussetzung für die nachwachsende Biomasse ist die nachhaltige Bewirtschaftung unserer Wälder, Äcker und Wiesen. Österreich gehört mit der aktiven Waldbewirtschaftung hier zu den Vorreitern. Wir entnehmen weniger Holz aus den Wäldern, als nachwächst. Abgesehen davon muss ein möglichst (klima-)effizienter Ressourceneinsatz stets die Grundlage unseres Handelns sein.

Leitveranstaltung des Bioenergiesektors

Mit mehr als 1.400 Teilnehmern aus der ganzen Welt ist die im Dreijahresrhythmus ausgerichtete Mitteleuropäische Biomassekonferenz CEBC die Leitveranstaltung der mitteleuropäischen Bioenergiebranche. Die zeitgleich stattfindende „Häuslbauer"-Messe mit rund 40.000 BesucherInnen und einem traditionellen Schwerpunkt in Bezug auf Energiebereitstellung im Gebäudesektor bietet dazu eine hervorragende Ergänzung. Besondere Highlights sind der **Waldtag** in Kooperation mit dem Ökosozialen Forum, das erste internationale **European Pellet Forum**, zahlreiche Workshops der **IEA-Bioenergie** und die Präsentation der **Highlights der Bioenergieforschung**.

Weitere Schwerpunkte werden auf die folgenden Bereiche gelegt:

- Nachhaltigkeit auf regionaler und nationaler Ebene sowie politische Rahmenbedingungen
- Klima-smarte Forst- und Holzwirtschaft
- Technologien für Bioraffinerien
- Negative Emissionen durch Pflanzenkohle und Bio-CCS
- Bioökonomie: Wärme, Strom und Treibstoffe
- Brennstoffcharakterisierung und Qualitätssicherung uvm.

Ein umfangreiches Exkursionsprogramm spannt den Bogen von der Theorie zur Praxis. Darüber hinaus bietet Ihnen ein vielseitiges Rahmenprogramm mit Social Events ausreichend Raum für Vernetzung.

Wir freuen uns darauf, Sie bei der **7. Mitteleuropäischen Biomassekonferenz CEBC2023** begrüßen zu dürfen.

ÖkR Franz Titschenbacher
Präsident des Österreichischen Biomasse-Verbandes & LK STMK

Mag. Norbert Totschnig, MSc
Bundesminister für Land- und Forstwirtschaft, Regionen & Wasserwirtschaft

Univ.-Prof. DI Dr. Hermann Hofbauer, *TU Wien, Vorsitzender des Wissenschaftlichen Komitees*

Bioenergy – Solutions for the energy and climate crisis

The Austrian Biomass Association, the Styrian Chamber of Agriculture and BEST - Bioenergy and Sustainable Technologies GmbH are hosting the **7th Central European Biomass Conference CEBC2023** in cooperation with Messe Congress Graz from 18th to 20th of January, 2023. The world is facing a radical change. Since the last conference three years ago, a pandemic broke out, Russia has started a war of aggression against Ukraine, and the consequences of climate change are being felt all over Europe.

The time to act is now!

We are in a very challenging situation, but we will have to deal with it. With bioenergy, we have created an innovative instrument for the future over the past few decades. Together with the other renewable energies wind, water, sun and corresponding energy saving measures, bioenergy contributes to getting out of the fossil energy dependency. The prerequisite for the regrowing biomass is the sustainable management of our forests, fields and meadows. With active forest management, Austria is one of the pioneers here. We take less wood from the forest than grows back. Apart from that, the most (climate) efficient use of resources must always be the basis of our actions.

Leading event of the bioenergy sector

Connecting more than 1,400 participants from all around the world, the triannually held conference belongs to the largest bioenergy industry events worldwide. The simultaneously held "Häuslbauer-trade fair", with its emphasis on the provision of energy in the building sector, reaching out to approximately 40,000 visitors, offers an excellent addition to the conference. Special highlights are the **Winter meeting** in cooperation with Ökosoziales Forum, the **First European Pellet Forum**, numerous workshops of the **IEA bioenergy** and the presentation of the **Highlights of Bioenergy Research**.

Additional topics include the following areas:

- Sustainability at regional and national level and political framework
- climate-smart forestry and timber management
- Technologies for biorefineries
- Negative Emissions through biochar and Bio-CCS
- Bioeconomy: Heat, Power and Fuels
- Fuel characterization and quality assurance and many more.

Numerous excursions to bioenergy destinations and the presentation of the leading companies in the sector link the theoretical approach of the conference to practical applications. The traditional conference dinner, held in the **Old University of Graz** and the daily open **Bioenergy-"Heurigen"** serve as excellent networking opportunities.

We are looking forward to welcoming you at the **7th Central European Biomass Conference CEBC2023**!

ÖkR Franz Titschenbacher
President of the Austrian Biomass Association & LK STMK

Mag. Norbert Totschnig, MSc
Federal Minister Ministry for Agriculture, Forestry, Regions & Water Management

Univ.-Prof. DI Dr. Hermann Hofbauer, *TU Wien, Chairman of the Scientific Committee*

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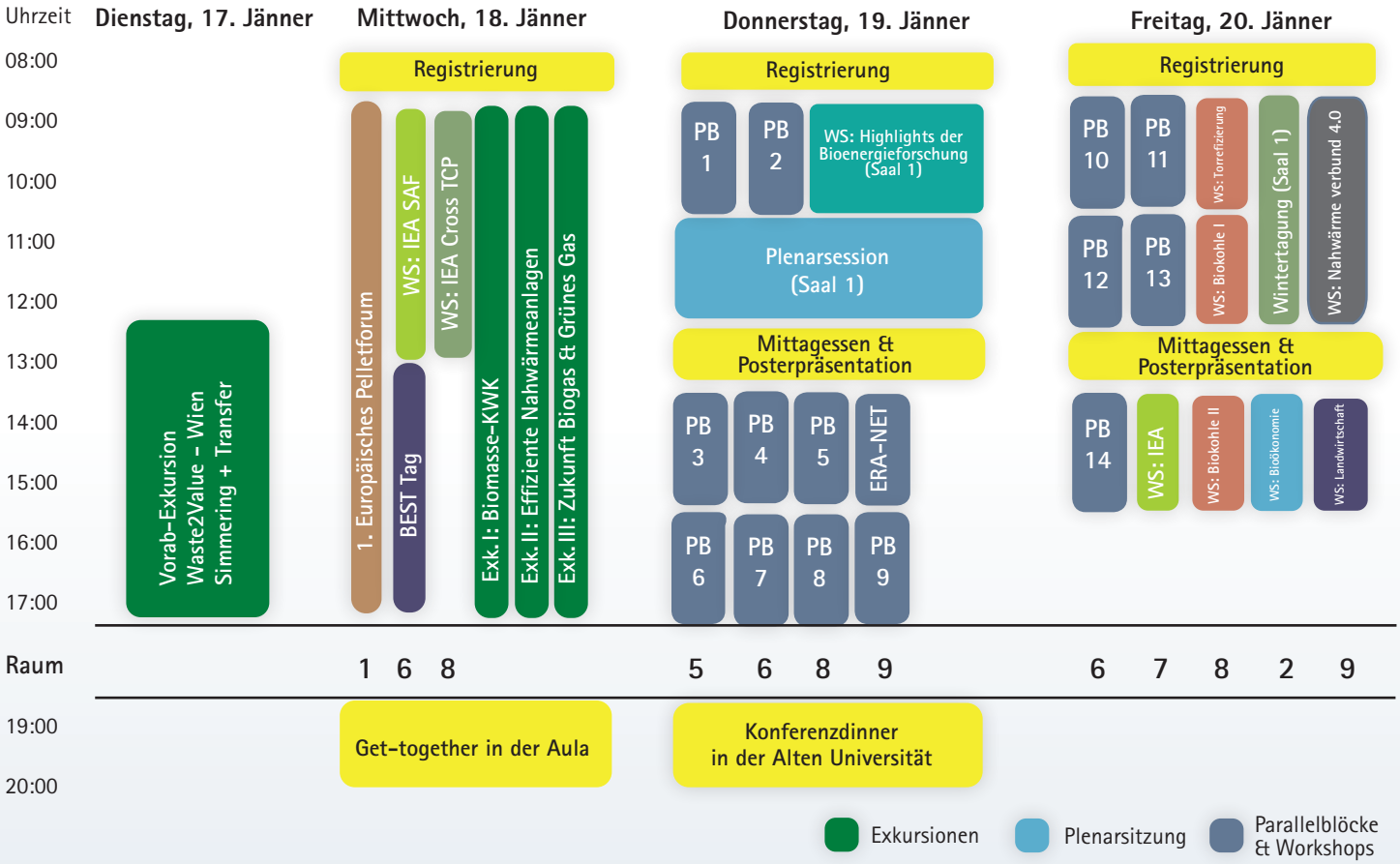
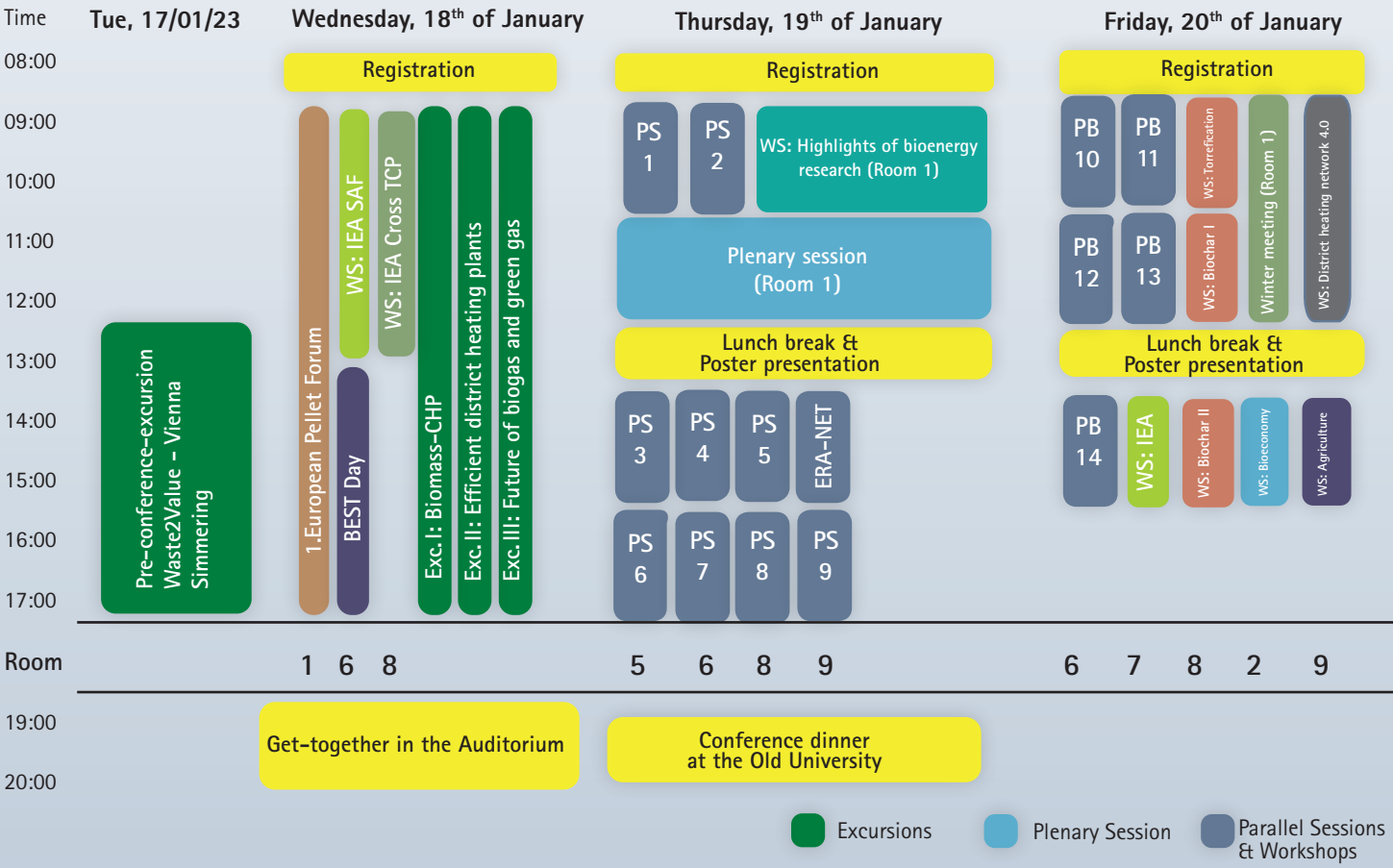


Exkursionen | Plenarsitzung | Parallelblöcke & Workshops

Programme of the 7th Central European Biomass Conference CEBC2023



Excursions | Plenary Session | Parallel Sessions & Workshops

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Mittwoch, 18. Jänner 2023

ab 08:00 **Registrierung**

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09:00-12:30 IEA AMF TCP Task 63. SAF Sustainable Aviation Fuels, **Saal 6,** S. 19

09:00-12:30 WS: IEA Cross TCP: Flexibilitätsbereitstellung, **Saal 8,** S. 21

12:30–13:30 **Mittagspause**

13:30–17:00 BEST Halbtag, **Saal 6,** S. 23

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09:00 - 10:30 PB 2: Biochemische Bioraffinerien, **Saal 6,** S. 26

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Vortragssprache im Detailprogramm gekennzeichnet: Vortragssprache **Englisch** Vortragssprache **Deutsch** **Simultanübersetzung**

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11:00 - 12:30 PS 12: Biomass fuel and ash characterization, **Room 6,** p. 46

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Language marked in the detailed programme: Language **English** Language **German** **Simultaneous translation**

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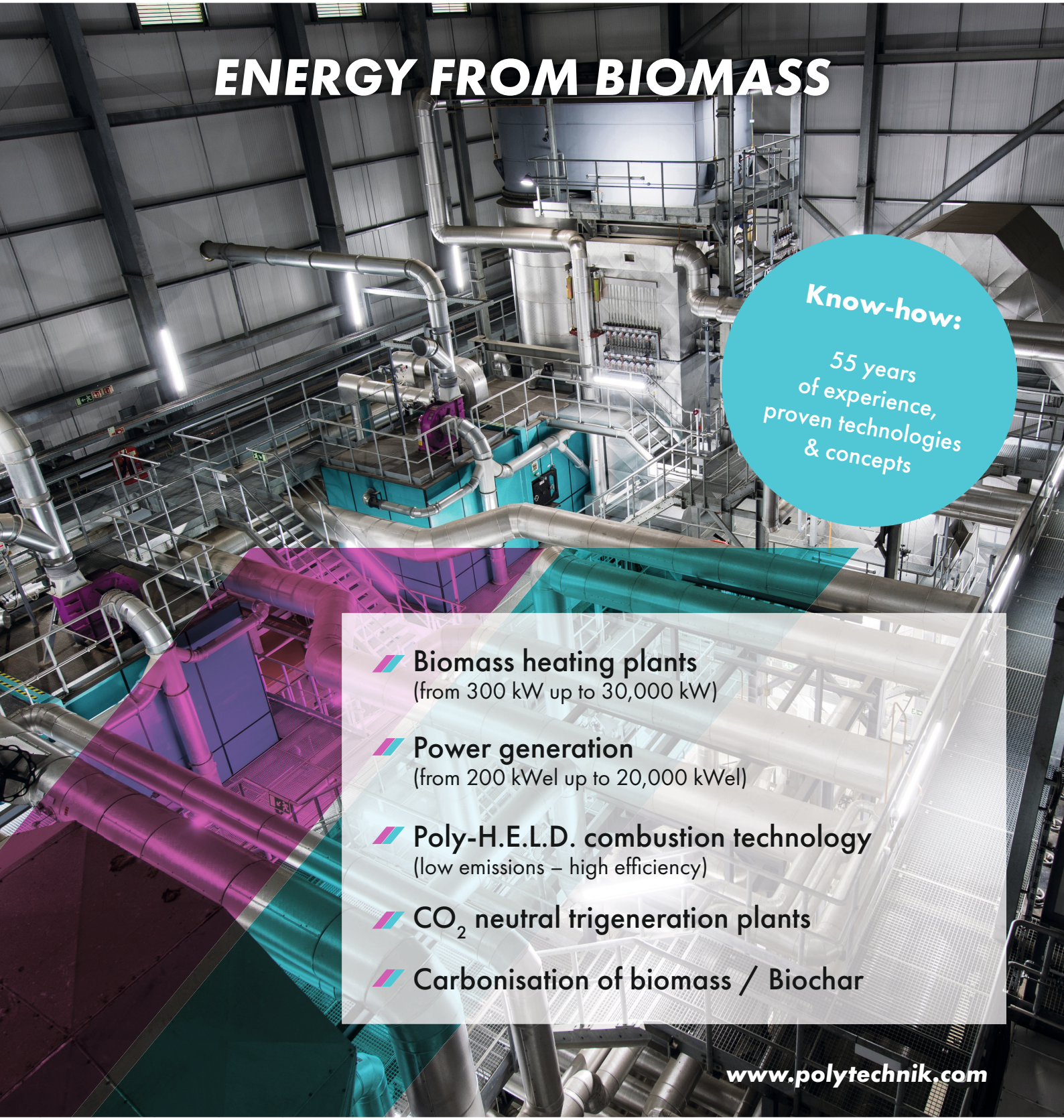

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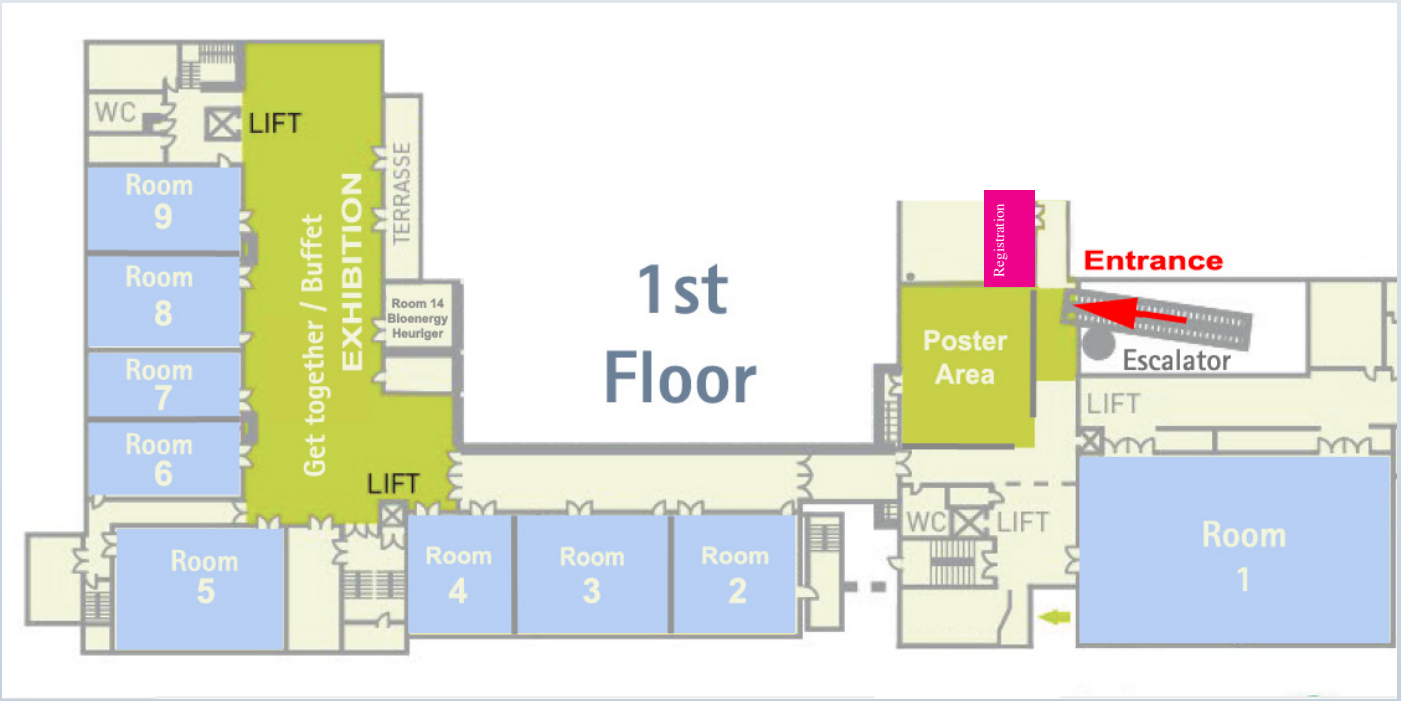
Messe Congress Graz: Floor Map

The rooms for the **7th Central European Biomass Conference CEBC2023** are located on the 1st floor of the Messe Congress Graz. You can reach the registration and the conference rooms with an escalator.



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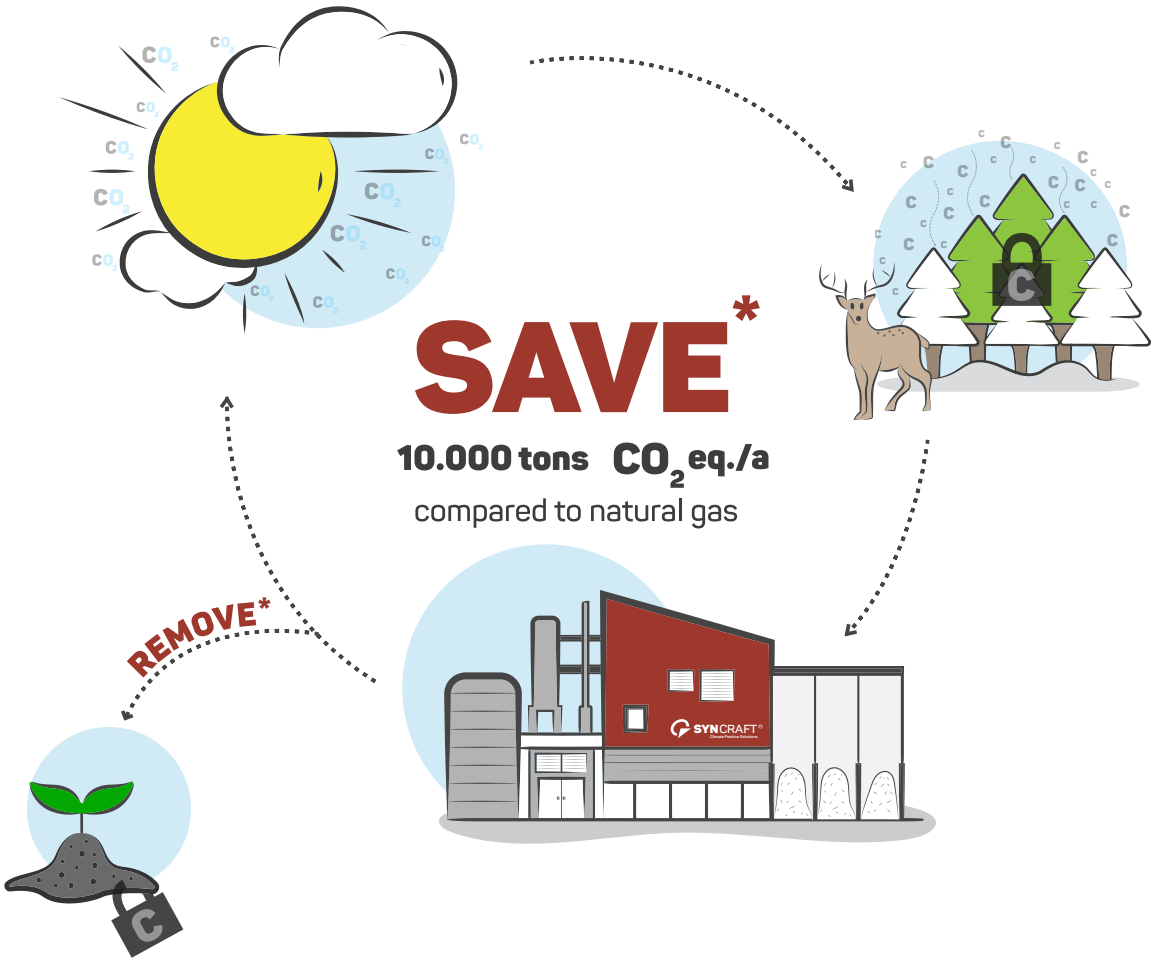

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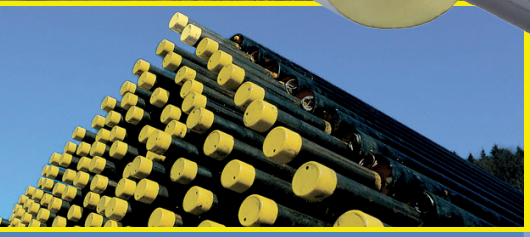

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Programm Teil 1

Exkursionen, Plenarsitzung, 1. Europäisches Pelletforum, BEST-Tag, IEA-Workshops

Teil 2 finden Sie ab Seite 224

Programme Part 1

Excursions, Plenary session, 1. European Pellet Forum, BEST-Day, IEA-Workshops

Part 2 you will find from page 224 on

Dienstag 17. Jänner

Vorab-Exkursion

Waste2Value - Wien Simmering mit Transfer nach Graz

13:00 Treffpunkt **11. Haidequerstraße 6, 1110 Wien**

- Für eine begrenzte Teilnehmerzahl (typischerweise für Reisende über Wien) bietet **BEST** – Bioenergy and Sustainable Technologies GmbH eine Führung durch ihre **Syngas Platform Wien** an. Kernelement ist ein 1 MW Dual Wirbelschicht Dampfvergaser der zweiten Generation. Diese Anlage ist speziell darauf ausgelegt, auch anspruchsvolle Einsatzstoffe wie minderwertige Biomasse, Klärschlamm oder sortierte Fraktionen von MSW zu verarbeiten.

Die Tour beinhaltet auch einen Besuch der nachgeschalteten Syntheseanlagen von BEST (z. B. die Fischer-Tropsch-Anlage mit 1 Barrel pro Tag), die direkt mit dem Vergaser verbunden sind.

Die Führung beginnt am **17. Jänner 2023 um 13:00 in der 11. Haidequerstraße 6, 1110 Wien-Simmering** (Eingang Gewerbeabfallverbrennungsanlage Wien Energie). Der Standort ist ca. 15 Minuten vom Flughafen Wien und 30 Minuten vom Stadtzentrum entfernt. Nach der Tour werden die Teilnehmer nach Graz (Messe) gebracht.

17:30 **Ankunft Graz**

Kosten EUR 100,-

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Rückfragen: office-wien@best-research.eu

Mittwoch 18. Jänner

Exkursion I
Biomasse-KWK

09:00 Abfahrt Messe Congress Graz

10:30 - 12:00 **FKF Forst- und Gutsverwaltung**
- 200 kWel Syncraft®-Holzgas KWK-Anlage - Wärme für Garnelenzucht
- Biokohle als Grillkohle

12:00 **Abfahrt**

12:15 - 13:15 Mittagessen

13:30 - 15:00 **Cycle Energy**
- Dampf-KWK 4,3 MWel 12 MWth
- Pelletierung
- Erzeugung von Prozessdampf für die Industrie

15:00 - 16:30 **Münzer Bioindustrie GmbH**
- Biodiesel aus Dampf-Wärme von Cycle Energy

18:00 Ankunft Messe Congress Graz

Excursions

Tuesday 17. January

Pre-conference-excursion

Waste2Value - Wien Simmering with transfer to Graz

13:00 Meeting point: **11. Haidequerstraße 6, 1110 Vienna**

- For a limited number of attendees (typically for those travelling via Vienna) BEST – Bioenergy and Sustainable Technologies GmbH offers a tour of its **Syngas Platform Vienna**. The core element of the platform is a 1 MW second generation Dual Fluidized Bed Steam Gasifier. This plant is specifically designed to also handle challenging feedstock, such as low quality biomass, sewage sludge or sorted fractions of MSW.

The tour will also include a visit of BEST's downstream synthesis plants (eg. the barrel per day Fischer-Tropsch plant), which are directly connected to the gasifier.

The tour will start on the **17th of January, 2023 at 13:00 at 11. Haidequerstraße 6, 1110 Wien-Simmering** (entrance to the industrial waste incineration plant of Wien Energie). The site is about 15 minutes from Vienna Airport and 30 minutes from the city centre. Attendees will be transferred to Graz (Messe) after the tour.

17:30 **Arrival Graz**

Cost EUR 100,-

Registration: https://best-research.eu/content/preconferenceexcursion
Further requiries: office-wien@best-research.eu

Wednesday 18. January

Excursion I
Biomass-CHP

09:00 Departure Messe Congress Graz

10:30 - 12:00 **FKF Forst- und Gutsverwaltung**
- 200 kWel Syncraft®-Wood gas CHP-plant - Heat for shrimp farming
- Biochar as barbecue charcoal

12:00 **Departure**

12:15 - 13:15 **Lunch**

13:30 - 15:00 **Cycle Energy**
- Steam-CHP 4,3 MWel 12 MWth
- **Pelleting**
- **Generation of process steam for industry**

15:00 - 16:30 **Münzer Bioindustry GmbH**
- Biodiesel from steam heat from Cycle Energy

18:00 Arrival Messe Congress Graz

Exkursionen

Mittwoch **18.** Jänner

Exkursion II
Effiziente Nahwärmeanlagen

09:00 Abfahrt Messe Congress Graz

10:00 - 12:00 **Nahwärme Strass**
- 3 MW Biomassekessel plus Absorptionswärmepumpe von Steps Ahead

12:00 **Abfahrt**

12:45 - 13:45 **Mittagessen**

14:00 - 16:00 **Stadtwerke Gleisdorf – Nahwärme**
- 800 kW mit Wärmepumpe aus Abwasser bei Kläranlage
- Faulgasnutzung

16:15 - 17:45 **Nahwärme St. Ruprecht a.d. Raab**
- 1.800 kW Biomassekessel
- 1.590 m² thermische Solaranlage und 138.000 Liter Pufferspeicher

18:30 Ankunft Messe Congress Graz

Exkursion III
Zukunft Biogas und Grünes Gas

10:00 Abfahrt Messe Congress Graz

10:30 - 11:30 **Energie Graz**
- Solares Speicherprojekt Helios Graz

12:15 - 13:30 **Mittagessen**

14:00 - 15:15 **Biogas Uidl**
- Zukunftsfitte Biogasanlagen - wo geht die Reise hin?

15:30 - 17:30 **Renewable Gas Field**
- Herstellung von grünem Wasserstoff und grünem Gas aus Biogas und PV-Überschussstrom

18:00 Ankunft Messe Congress Graz

Organisatorisches: Der Treffpunkt für Exkursion I und II ist um 08:30 Uhr bei der Konferenzregistrierung, der für Exkursion III um 09:30. Die Abfahrt für die Exkursionen erfolgt nach der Registrierung (Treffpunkt 1. Stock Messe Congress Graz).
Vortragssprache: deutschsprachige Führung mit englischsprachiger Begleitung

Excursions

Wednesday **18.** January

Excursion II
Efficient district heating plants

09:00 Departure Messe Congress Graz

10:00 - 12:00 **Nahwärme Strass**
- 3 MW Biomass boiler plus absorption heat pump from Steps Ahead

12:00 **Departure**

12:45 - 13:45 **Lunch**

14:00 - 16:00 **Stadtwerke Gleisdorf – Nahwärme**
- 800 kW with heat pump from waste water at sewage treatment plant
- utilization of digester gas

16:15 - 17:45 **Nahwärme St. Ruprecht a.d. Raab**
- 1.800 kW Biomass boiler
- 1.590 m² thermic solar plant and 138.000 Liter buffer tank

18:30 Arrival Messe Congress Graz

Excursion III
Future of Biogas and Green Gas

10:00 Departure Messe Congress Graz

10:30 - 11:30 **Energie Graz**
- Solar storage project Helios Graz

12:15 - 13:30 **Lunch**

14:00 - 15:15 **Biogas Uidl**
- Future-proof biogas plants - where are we heading?

15:30 - 17:30 **Renewable Gas Field**
- **Production of green hydrogen and green gas from biogas and excess PV power**

18:00 Arrival Messe Congress Graz

Organisation: The meeting point for Excursion I and II is at 08:30, for Excursion III at 09:30 at the conference registration. Departure starts after a successful registration (meeting point 1st floor, Messe Congress Graz).
Language: German-speaking guides with English-speaking support

Eschlböck
BIBER wood chippers
www.eschlboeck.at

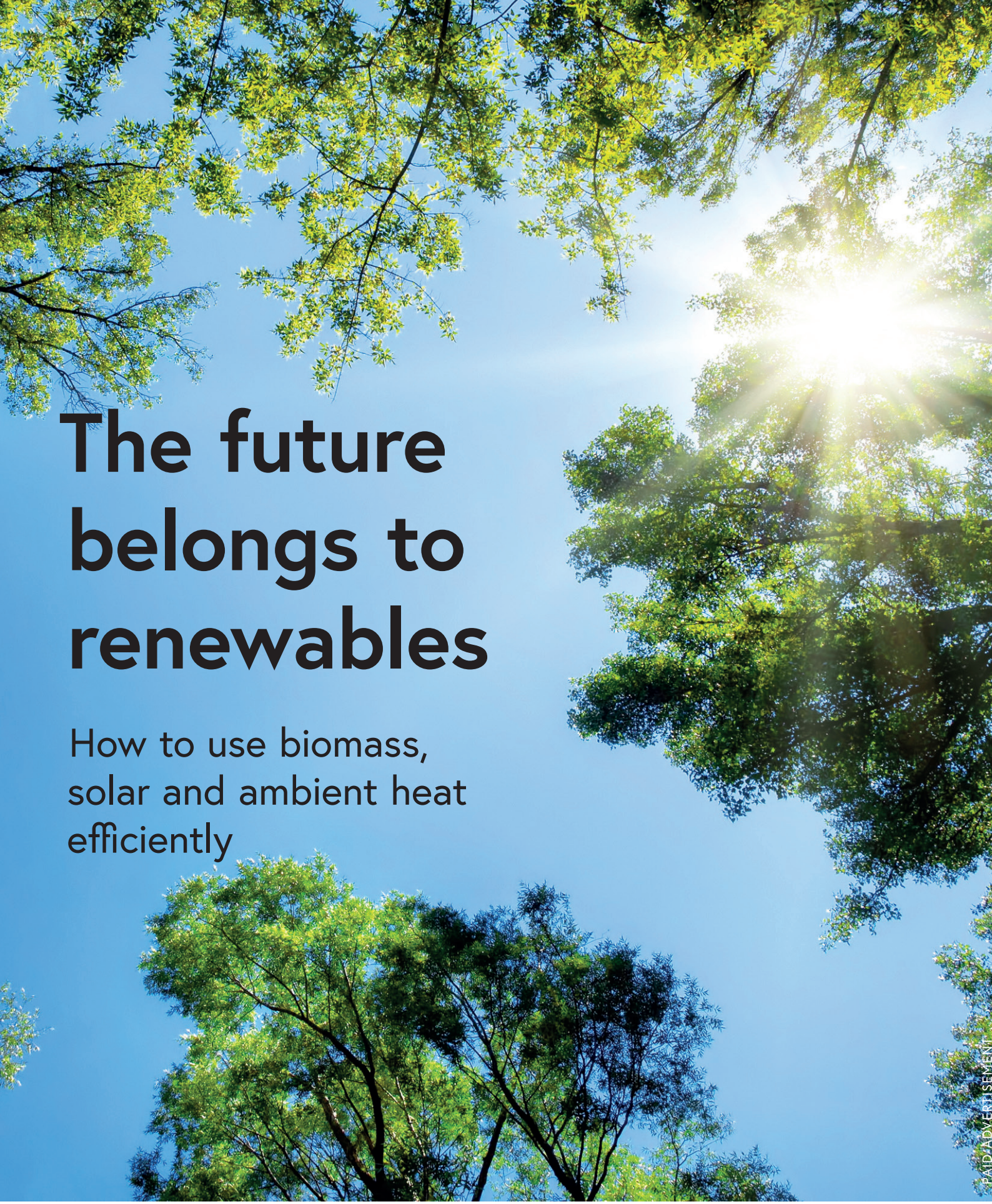
DPLF GS geprüfte Sicherheit

less CO2 in wood chipping

Under the brand name BIBER, the upper Austrian family business Eschlböck develops and produces woodchippers for entrepreneurs in biomass shredding as well as an own product line for foresting, agriculture and professional gardening.

In addition to their robustness and durability, the Biber disc wheel chippers are characterized by a large disc wheel. This provides outstanding performance values, saves fuel and produces precise chippings. A new GS-tested safety edge enables practicable work. Eschlböck offers a completely screwed instead of welded chipping rotor which ensures an extended life cycle of the entire machine. Considering sustainability all parts can be replaced separately in case of abrasion.

With the development and construction of the Biber Powertruck series, the chipper specialist Eschlböck increasingly became a specialist in vehicle construction. VICAN, VICTOR and MAROX with a unique power truck drive, all-wheel drive and 510-750 hp belong to the strongest and most efficient chippers on the market. They offer lowest power losses and therefore lower CO2 emissions.



Federal Ministry
Republic of Austria
Climate Action, Environment,
Energy, Mobility,
Innovation and Technology

klimaaktiv

Benefit from klima**aktiv** know-how on sustainable heating with renewables, possible uses of renewable raw materials and wood flows in Austria. Find out more at **klimaaktiv.at/renewables**.

1. Europäisches Pelletforum, Saal 1, 09:00 – 17:00

Pelleteinsatz am Wärmemarkt – aktuelle Entwicklungen und Ausblick

EUROPEAN PELLET FORUM AUSTRIA | 18TH JANUARY 2023

Mittwoch 18. Jänner

„Die europäischen Pelletmärkte sind aktuell von einem rasanten Wachstum und einer enormen Volatilität gekennzeichnet. Das 1. Europäische Pelletforum bietet eine ideale Gelegenheit, sich in dieser turbulenten Zeit ein Bild von den aktuellen Entwicklungen zu machen und sich mit BranchenvertreterInnen aus ganz Europa auszutauschen."

Chair: Christian Rakos,
Geschäftsführer proPellets Austria, AUT

09:00 - 10:00 – Internationale Marktentwicklung

Big picture – Jüngste Entwicklungen auf den internationalen Pellet-märkten, Gilles Gauthier, *Hawkins Wright ltd., GBR*

Marktsituation von Pellets in Südosteuropa
Branko Glavonjic, *Universität Belgrad, SRB*

Den angespannten Pelletmarkt meistern – Erfahrungen aus Österreich
Christian Rakos, *proPellets Austria, AUT*

10:00 - 11:00 – Paneldiskussion mit europäischen Pelletverbänden: aktuelle Entwicklungen und Zukunftsperspektiven

Pablo Rodero, *Avebiom, SPA*
Eric Vial, *Propellet France, FRA*
Martin Bentele, *Deutscher Energieholz- und Pellet-Verband e.V., DEU*
Matteo Favero, *AIEL, ITA*
Adam Sarnaszek, *Biocontrol, POL*

11:00 - 11:30 – Kaffeepause

11:30 - 12:15 – Politische Situation und Kommunikation

Status der RED III-Verhandlungen und anderer wichtiger politischer Dossiers in Brüssel, Irene di Padua,
Bioenergy Europe, BEL

Bewältigung der Kommunikationsherausforderungen der Pelletsbranche, tbd.

12:15 - 12:45 Speed-Dating der Teilnehmenden zur Unterstützung des Networkings

12:45 - 14:00 Mittagspause

14:00 - 15:30 Marktsituation aus Sicht der Industrie

Marktentwicklung von Pelletpressen, Lars Bloch, *Andritz, DNK*

Marktausblick für Pelletkessel, Stefan Ortner, *ÖkoFEN, AUT*

Ausblick Pelletöfen, Marco Palazzetti, *Palazzetti, ITA*

Perspektiven eines Pelletproduzenten, Helmut Schellinger, *Schellinger KG, DEU*

Die Landschaft des Pellethandels, Michael Christensen,
CM Biomass, DNK

Umstellung der Energieversorgung der Industrie auf Pellets
tbd.

15:30 - 16:00 Kaffeepause

16:00 - 17:00 Untermauerung der Argumente für Holzpellets – Stimmen aus der Wissenschaft

Biomasse und Klimaschutz, tbd.

Ökobilanz / CO_2-Bilanz verschiedener Waldnutzungsszenarien
Hubert Röder, *Fachhochschule Weihenstephan-Triesdorf, GER*

Emissionsminderung von Pelletkesseln, *Ingwald Obernberger, TU Graz, AUT*

17:00 NETWORKING & FLYING DINNER

Nähere Informationen finden Sie unter: **www.pellet-forum.eu**

Vortragssprache Englisch

EUROPEAN PELLET COUNCIL · EN plus · pro»pellets Austria

1st European Pellet Forum, Room 1, 09:00 – 17:00

Use of Pellets in the Heating Market – Current Developments & Prospects

EUROPEAN PELLET FORUM AUSTRIA | 18TH JANUARY 2023

Wednesday 18. January

„The European pellet markets are currently characterized by rapid growth and enormous volatility. The European Pellet Forum offers an ideal opportunity to get an idea of the current developments in these turbulent times and to exchange ideas with industry representatives from all over Europe."

Chair: Christian Rakos,
CEO proPellets Austria, AUT

09:00 - 10:00 – International Market Development

Big picture – Recent developments in international pellet markets
Gilles Gauthier, *Hawkins Wright Ltd., GBR*

Pellet market situation in Southeastern Europe
Branko Glavonjic, *University of Belgrade, SRB*

Coping with tight pellet markets – the Austrian experience
Christian Rakos, *proPellets Austria, AUT*

10:00 - 11:00 Panel debate with European Pellet Associations: Current developments and future perspectives

Pablo Rodero, *Avebiom, SPA*
Eric Vial, *Propellet France, FRA*
Martin Bentele, *Deutscher Energieholz- und Pellet-Verband e.V., GER*
Matteo Favero, *AIEL, ITA*
Adam Sarnaszek, *Biocontrol, POL*

11:00 - 11:30 – Coffee Break

11:30 - 12:15 – Policy situation and communication

Status of RED III negotiations and other important policy files in Brussels, Irene di Padua, *Bioenergy Europe, BEL*

Managing communication challenges of the pellet sector, tbd.

12:15 - 12:45 Speed dating of participants to facilitate networking

12:45 - 14:00 Lunch break

14:00 - 15:30 Market Situation from Industry

Market development of pellet mills, Lars Bloch, *Andritz, DNK*

Pellet boiler market outlook, Stefan Ortner, *ÖkoFEN, AUT*

Pellet stove outlook, Marco Palazzetti, *Palazzetti, ITA*

Perspectives of a pellet producer, Helmut Schellinger, *Schellinger KG, GER*

The pellet trading landscape, Michael Christensen, *CM Biomass, DNK*

Converting the energy supply of industries to pellets,
tbd.

15:30 - 16:00 Coffee Break

16:00 - 17:00 Underpinning the case for wood pellets – Voices of Science

Biomass and climate mitigation, tbd.

Ecobalance / CO_2 balance of different Forest use scenarios
Hubert Röder, *Fachhochschule Weihenstephan-Triesdorf, GER*

Emission reduction of pellet boilers, *Ingwald Obernberger, TU Graz, AUT*

17:00 NETWORKING & FLYING DINNER

Detailed information can be found at: **www.pellet-forum.eu**

Language English

EUROPEAN PELLET COUNCIL · EN plus · pro»pellets Austria

WS: IEA AMF TCP Task 63: Sustainable Aviation Fuels

Vortragssprache **Englisch**

Mittwoch **18.** Jänner

Nationale Strategien und Herausforderungen für die Markteinführung von nachhaltigen Flugtreibstoffen, Saal 6, 09:00 – 12:30

„International abgestimmte politische Maßnahmen sind bei der Markteinführung von nachhaltigen Flugtreibstoffen essentiell."

Chair: Dina Bacovsky, BEST, *AUT*

„Nachhaltige Flugtreibstoffe bergen ein großes Potenzial die Emissionen des Flugverkehrs zu senken."

Co-Chair: Doris Matschegg, *BEST, AUT*

09:00 **Beginn**

Der IEA AMF TCP Task 63 organisiert einen internationalen Workshop über nachhaltige Flugkraftstoffe. Der Workshop befasst sich mit dem Status quo, den Herausforderungen bei der Markteinführung und den nationalen Strategien zur Bewältigung dieser Herausforderungen.

Nachhaltige Flugtreibstoffe haben das Potenzial, die Treibhausgasemissionen des Luftfahrtsektors zu verringern. Dieses Potenzial bleibt jedoch weitgehend ungenutzt, da solche Treibstoffe derzeit nur 0,05 % des gesamten Flugtreibstoffverbrauchs ausmachen. Ziel von Task 63 ist es, die Grundlage für gemeinsame F&E-Arbeiten zu nachhaltigen Flugtreibstoffen innerhalb von AMF TCP zu schaffen. Daher konzentriert sich der Task darauf, InteressenvertreterInnen und ExpertInnen zu identifizieren, die nationale Situation der TeilnehmerInnen zu bewerten und den Informationsaustausch über die wichtigsten Herausforderungen bei der Einführung nachhaltiger Flugtreibstoffe zu erleichtern.

Das Technology Collaboration Programme on Advanced Motor Fuels (AMF) der IEA zielt darauf ab, den Verkehr auf den Weg der Nachhaltigkeit zu bringen und die verkehrsbedingten Umweltauswirkungen zu verringern, indem es die Zusammenarbeit in Forschung, Entwicklung und Bereitstellung fördert und unvoreingenommene Informationen über saubere, energieeffiziente und nachhaltige Treibstoffe und die damit verbundenen Motoren- und Fahrzeugtechnologien bereitstellt.

Das vollständige Programm wird auf der Taskwebsite bekannt gegeben. *https://iea-amf.org/content/events/web_seminars/workshop_task63_cebc*

12:30 **Ende**

BEST Bioenergy and Sustainable Technologies

IEA-AMF Technology Collaboration Programme on Advanced Motor Fuels

klima+ energie fonds

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

WS: IEA AMF TCP Task 63: Sustainable Aviation Fuels

Language **English**

Wednesday **18.** January

National strategies and challenges for the market uptake of Sustainable Aviation Fuels, Room 6, 09:00 – 12:30

„Internationally coordinated policies are essential in bringing Sustainable Aviation Fuels to market."

Chair: Dina Bacovsky, BEST, *AUT*

„SAF hold great potential for reducing emissions from aviation."

Co-Chair: Doris Matschegg, *BEST, AUT*

09:00 **Opening**

The IEA AMF TCP Task 63 is organizing an international workshop on sustainable aviation fuels. The workshop includes status quo, challenges for market introduction and national strategies to overcome those challenges.

Sustainable aviation fuels have the potential to reduce greenhouse gas emissions from the aviation sector. However, this potential remains largely untapped as such fuels currently represent only 0.05% of total jet fuel consumption. The aim of Task 63 is to lay the foundation for collaborative RD&D work on sustainable aviation fuels within AMF TCP. Thus, the Task is focusing on identifying stakeholders and experts, assessing the national situation of the participants, and facilitating information exchange on the main challenges in launching sustainable aviation fuels.

This international workshop serves to present and discuss the task results, complemented with external presentations.

The IEA´s Technology Collaboration Programme on Advanced Motor Fuels (AMF) aims at putting transport on track to sustainability and reducing environmental impacts from transport by fostering collaborative research, development, deployment and providing unbiased information on clean, energy-efficient and sustainable fuels and related engine and vehicle technology.

The full programme will be announced on the task website: *https://iea-amf.org/content/events/web_seminars/workshop_task63_cebc*

12:30 **End**

BEST Bioenergy and Sustainable Technologies

IEA-AMF Technology Collaboration Programme on Advanced Motor Fuels

klima+ energie fonds

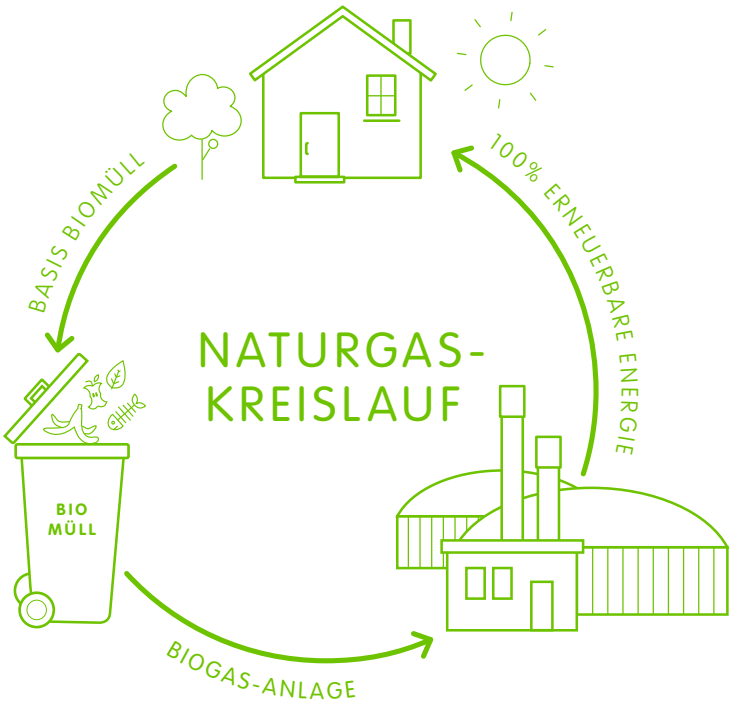
Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

NATURGAS IM FAKTENCHECK

Was ist eigentlich Naturgas?
Naturgas = Grünes Gas = Biomethan = 100 % erneuerbar

Wie wird Naturgas hergestellt?

Küchen- und Gewerbeabfälle sowie Kompost und andere organische Stoffe werden gesammelt und in einer speziellen Anlage unter Luftabschluss vergoren. Das daraus entstandene Biogas wird auf Erdgasqualität aufbereitet. Es entspricht strengsten Anforderungen und ist zu 100 % erneuerbare Energie. Naturgas ist CO_2-neutral und feinstaubfrei.



Naturgas als Partner der Energiewende

Umweltfreundliches Erdgas kann klimaschonend durch CO_2-neutrales Naturgas ersetzt werden und wird so zum perfekten Partner der erneuerbaren Energien. Die eingespeisten Mengen werden jährlich durch autorisierte Stellen kontrolliert, ähnlich wie beim Ökostrom und werden dann den KundInnen von den Energielieferanten angeboten. Dieses grüne Gas kann auch in großen Mengen gespeichert werden.

Ihre Vorteile mit erneuerbarem Naturgas:

Grünes Naturgas, (auch) aus der Steiermark für die Steiermark, erhöht die regionale Wertschöpfungskette und damit die Versorgungssicherheit. Es wird vom Land Steiermark als erneuerbarer Energieträger anerkannt.

Endlich richtig Gas geben!

Alle ErdgaskundInnen können ohne Umstellungen einfach umsteigen und die bestehende Heizungsanlage ganz normal weiter nutzen. Weitere Infos unter www.e-netze.at oder unter 0316 90555

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MADE IN AUSTRIA USED GLOBALLY

Workshop: IEA-Cross-TCP: Wege zu einer flexiblen, sektorübergreifenden Energieversorgung mit besonderem Fokus auf die Flexibilitätsbereitstellung über den Wärmesektor; Saal 8, 09:00 - 12:30

Mittwoch 18. Jänner

„Ein nachhaltiges Energie- und Ressourcensystem erfordert ein intelligentes, sektorübergreifendes Zusammenspiel verschiedener nachhaltiger Technologien. Hierzu gilt es die Flexibilität steuerbarer Technologien deutlich zu verbessern, sodass sie die Volatilität nicht steuerbarer Technologien kompensieren können."

Chair: Markus Gölles, *BEST, AUT*

Eine nachhaltige Energieversorgung kann nur durch ein flexibles, sektorübergreifendes Energiesystem erreicht werden, das die spezifischen Vorteile der verschiedenen erneuerbaren Technologien nutzt. In diesem Workshop werden die möglichen Rollen der verschiedenen Technologien auf der Grundlage einer vorangegangenen Diskussion über die Anforderungen der Nutzer in den verschiedenen Sektoren diskutiert. Dabei soll ein besonderer Schwerpunkt auf die Flexibilitätsbereitstellung durch den Wärmesektor gelegt werden. Durch das Zusammenbringen verschiedener Nutzer, die die kommunale und industrielle Energieversorgung repräsentieren, und Technologieexperten aus verschiedenen IEA Technology Collaboration Programmes (TCP) soll der Workshop eine ganzheitliche Diskussion unterstützen.

09:00 **Beginn**

Block A – Künftige Anforderungen der Nutzer und die besondere Rolle der Biomasse

Vision der Wien Energie für eine nachhaltige Energie- und Ressourcenversorgung von Wien
Teresa Schubert, *Wien Energie, AUT*

Kommunale Energiesysteme im kleinen Maßstab
tbd.

Digitalisierung von Energiemanagementsystemen – Optimierung innerbetrieblicher Energienutzung
Maria Lechner, *INNIO Jenbacher, AUT*

Flexible Bioenergie und Systemintegration
Elina Mäki, *VTT Technical Research Centre of Finland, FIN*

10:30 **Kaffeepause**

11:00 **Block B – Bereitstellung von Flexibilität durch den Wärmesektor**

Transformation von Fernwärme- und Fernkältesystemen hin zu einem hohen Anteil an erneuerbaren Energien
Ingo Leusbrock, *AEE INTEC & IEA DHC Annex TS5, AUT*

Möglichkeiten durch Langzeitwärmespeicher und solarthermische Großanlagen
Viktor Unterberger, *BEST & IEA SHC Task 68, AUT*

Möglichkeiten durch Digitalisierung am Beispiel von Fernwärme und Fernkälte
Dietrich Schmidt, *Fraunhofer IEE & IEA DHC Annex TS4, DEU*

12:00 **Interaktive Diskussion mit den Vortragenden und dem Publikum**

12:30 **Mittagspause**

BEST Bioenergy and Sustainable Technologies

Vortragssprache **Englisch**

WS: IEA-Cross-TCP: Towards a flexible, cross-sectoral energy supply

With a special focus on the flexibility provision via the heating sector
Room 8, 09:00 - 12:30

Wednesday 18. January

„A sustainable energy and resource system requires intelligent, cross-sectoral interaction of different sustainable technologies. To achieve this, the flexibility of controllable technologies must be significantly improved so that they can compensate for the volatility of non-controllable technologies."

Chair: Markus Gölles, *BEST, AUT*

A sustainable energy supply can only be achieved by a flexible, cross-sectoral energy system utilizing the specific advantages of the various renewable technologies. In this workshop possible roles of different technologies will be discussed based on a previous discussion of the users' needs among the different sectors. A special focus will be given on the flexibility provision via the heating sector. By bringing together different users, representing municipal and industrial energy supply, and technological experts from different IEA Technology Collaboration Programmes (TCP) the workshop will encourage a holistic discussion.

09:00 **Opening**

Block A – Future needs of users and the specific role of biomass

Wien Energie's vision of a sustainable energy and resource supply of Vienna
Teresa Schubert, *Wien Energie, AUT*

Small-scale municipal energy system
tbd.

Digitalization of energy management systems- optimization of internal energy use as an industrial company
Maria Lechner, *INNIO Jenbacher, AUT*

Flexible Bioenergy and System Integration
Elina Mäki, *VTT Technical Research Centre of Finland, FIN*

10:30 **Coffee Break**

11:00 **Block B – Flexibility provision via the heating sector**

Transformation of District Heating and Cooling Systems towards high share of renewables
Ingo Leusbrock, *AEE INTEC & IEA DHC Annex TS5, AUT*

Opportunities offered by long-term heat storages and large-scale solar thermal systems
Viktor Unterberger, *BEST & IEA SHC Task 68, AUT*

Possibilities through digitalization on the example of District Heating and Cooling
Dietrich Schmidt, *Fraunhofer IEE & IEA DHC Annex TS4, DEU*

12:00 **Interactive discussion of audience and presenters**

12:30 **Lunch break**

BEST Bioenergy and Sustainable Technologies

Language **English**

BEST-Halbtag: Nachhaltige Bioraffinerien und Digitalisierung

Vortragssprache Englisch

Mittwoch 18. Jänner

Saal 6, 13:30 – 17:00

„BEST hat sich laufend von der überwiegend technologisch orientierten Forschung in Richtung der Entwicklung von Prozessketten und der Systemintegration von Technologien weiterentwickelt. Heute sind digitale Methoden und Werkzeuge unsere wertvollen Begleiter, mit deren Hilfe wir die industrielle Umsetzung von nachhaltigen Bioraffinerien und erneuerbaren Energietechnologien unterstützen."

Chair: Walter Haslinger, *BEST, AUT*

Der BEST Tag bietet Highlights der industrie-relevanten Forschungsaktivitäten von BEST und fokussiert auf nachhaltige Bioraffinerien und Digitalisierung als Enabler für erfolgreiche Technologieentwicklung und -implementierung.

13:30 **Block 1: Bioraffinerien**

Erkenntnisse aus der Biomasseverbrennung für zukünftige Bioenergieanwendungen
Manuel Schwabl, *Fixed Bed Conversion Systems*

Perspektiven zur Dekarbonisierung und regionalen Bereitstellung grüner Kohlenstoffprodukte
Elisabeth Wopienka, *Fixed Bed Conversion Systems*

Biokonversionsverfahren für erneuerbare Energie und/oder biologische Kohlenstoffabscheidung und -nutzung
Bernhard Drosg, *Bioconversion Systems*

Biomasse-Gaserzeugung der 2. Generation: Syngas Plattform Wien – aktueller Status und Ausblick
Matthias Kuba, *Fluidized Bed Conversion Systems*

Nutzung von Syngas für die Herstellung von Treibstoffen und Chemikalien – aktuelle Entwicklungen und Ausblick
Gerald Weber, *Fluidized Bed Conversion Systems*

15:00 **Kaffeepause**

15:30 **Block 2: Digitale Methoden, Werkzeuge und Nachhaltigkeit**

Evaluierung verschiedener numerischer Modelle für die Vorhersage der NOx-Emissionen von Biomassekleinfeuerungen
Michael Essl, Modelling & Simulation

Digitalisierung als Basis für den effizienten und flexiblen Betrieb von erneuerbaren Energietechnologien
Markus Gölles, *Automation & Control*

Intelligente Regelung gekoppelter Wärmenetze
Valentin Kaisermayer, *Automation & Control*

Integrierte Energielösungen für eine dezentrale Energiezukunft – Herausforderungen und Lösungsansätze
Michael Zellinger, *Smart- & Microgrids*

Das Wood-Value-Tool: Techno-ökonomische Bewertung des holzverarbeitenden Sektors in Österreich
Marilene Fuhrmann, *Sustainable Supply & Value Chains*

17:00 **Ende**

FFG Forschung wirkt. | Bundesministerium Arbeit und Wirtschaft | Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie | wirtschaftsagentur wien – Für die Stadt Wien | Niederösterreich | Das Land Steiermark – Wirtschaft, Tourismus, Regionen, Wissenschaft und Forschung | SFG – Neues denken. Neues fördern. | BEST – Bioenergy and Sustainable Technologies

BEST-Day: Sustainable biorefineries and digitalization, Room 6, 13:30 – 17:00

Language English

Wednesday 18. January

„BEST has continuously developed from mostly technology related research towards a strong focus on full process chains and system integration. Today, digital methods and tools are our valuable companions for supporting industrial implementation of sustainable biorefineries and renewable energy technologies."

Chair: Walter Haslinger, *BEST, AUT*

The BEST day provides highlights of industry relevant research activities of BEST and focusses on sustainable biorefineries and digitalization as enabler for successful technology development and technology implementation.

13:30 **Session 1: Biorefineries**

Learnings from biomass combustion towards future bioenergy applications
Manuel Schwabl, *Fixed Bed Conversion Systems*

Green Carbon perspectives for regional sourcing and decarbonization
Elisabeth Wopienka, *Fixed Bed Conversion Systems*

Bioconversion processes for renewable energy and/or biological carbon capture and utilisation
Bernhard Drosg, *Bioconversion Systems*

Second generation biomass gasification: The Syngas Platform Vienna – current status and outlook
Matthias Kuba, *Fluidized Bed Conversion Systems*

Utilization of syngas for the production of fuel and chemicals – recent developments and outlook
Gerald Weber, *Fluidized Bed Conversion Systems*

15:00 **Coffee break**

11:00 **Session 2: Digital methods, tools and sustainability**

Evaluation of different numerical models for the prediction of NOx emissions of small-scale biomass boilers
Michael Essl, Modelling & Simulation

Digitalization as the basis for the efficient and flexible operation of renewable energy technologies
Markus Gölles, *Automation & Control*

Smart Control for Coupled District Heating Networks
Valentin Kaisermayer, *Automation & Control*

Integrated energy solutions for a decentral energy future – challenges and solutions
Michael Zellinger, *Smart- & Microgrids*

Wood-Value-Tool: Techno-economic assessment of the forest-based sector in Austria
Marilene Fuhrmann, *Sustainable Supply & Value Chains*

17:00 **End**

FFG Forschung wirkt. | Bundesministerium Arbeit und Wirtschaft | Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie | wirtschaftsagentur wien – Für die Stadt Wien | Niederösterreich | Das Land Steiermark – Wirtschaft, Tourismus, Regionen, Wissenschaft und Forschung | SFG – Neues denken. Neues fördern. | BEST – Bioenergy and Sustainable Technologies

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Plenarsitzung

Lösungen für die Energie- und Umweltkrise, Saal 1, 11:00 – 12:30

Moderation: **Andreas Jäger,** *Klimajäger & ORF-Journalist*

11:00 Wissenschaftliche & Politische Eröffnung

Eröffnung & Begrüßung
- **Franz Titschenbacher,** *Präsident ÖBMV & LK STMK*
- **Günter Liebel,** *Generalsekretär Bundesministerium für Land- und Forstwirtschaft, Regionen & Wasserwirtschaft*
- **Hermann Hofbauer,** *TU Wien & Vorsitzender Wissenschaftliches Komitee*

Grußworte durch die **Energie Steiermark**

Die Energie- und Klimastrategie der Bundesregierung,
Leonore Gewessler, *Bundesministerin für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie*

Filmpremiere: Der natürliche Kohlenstoffkreislauf

„Bei der Bioenergie-Technologie und -Forschung ist Österreich durch die Forschungsmaßnahmen des Klimaschutzministeriums weltweiter Spitzenreiter. Die Mitteleuropäische Biomassekonferenz bietet dabei die passende Plattform, um Forschungsergebnisse zu präsentieren und die mögliche Bedeutung der Bioenergie zur Erreichung der Energie- und Klimaziele zu unterstreichen."

Leonore Gewessler, *Bundesministerin, BMK*

Donnerstag 19. Jänner

Impulsvortrag: Neue Wege im Klimaschutz: Negative Emissionen mit Bioenergie, **Tobias Pröll**, BOKU

Podiumsdiskussion: Bioenergie - Lösungen für die Energie- und Umweltkrise

- **Leonore Gewessler,** *Bundesministerin für Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie*
- **Günter Liebel,** *Generalsekretär Bundesministerium für Land- und Forstwirtschaft, Regionen & Wasserwirtschaft*
- **Franz Titschenbacher,** *Präsident ÖBMV & LK STMK*
- **Simone Schmiedtbauer**, *EU-Abgeordnete*
- **Tobias Pröll**, BOKU
- **Franz Maier,** *Umweltdachverband*
- **Bernd Vogl,** *Klima- und Energiefonds*

Simultanübersetzung

12:30 - 13:30 **Mittagspause & Posterpräsentation**




Plenary Session

Simultaneous translation

Solutions for the energy and climate crisis, Room 1, 11:00 – 12:30

Host: **Andreas Jäger,** *Klimajäger & ORF-Journalist*

11:00 Scientific & Political Opening

Opening Statements:
- **Franz Titschenbacher,** *President ÖBMV & LK STMK*
- **Günter Liebel,** *General Secretary, Federal Ministry of Agriculture, Forestry, Regions and Water Management*
- **Hermann Hofbauer,** *TU Wien & Chair of the Scientific Committee*

Opening remarks by **Energie Steiermark**

The energy and climate strategy of the Federal Government,
Leonore Gewessler, *Federal Minister for Climate Action, Environment, Mobility, Innovation and Technology*

Movie premiere: The natural carbon cycle

„Austria is a global leader in bioenergy technology and research with its research programs. The Highlights of Bioenergy Research present a comprehensive overview of the latest developments and potential contributions to achieving energy and climate goals."

Leonore Gewessler, *Bundesministerin, BMK*

Thursday 19. January

Keynote: New ways for climate protection: negative emissions with bioenergy, **Tobias Pröll**, BOKU

Panel discussion: Bioenergy - Solutions for the energy and climate crisis

- **Leonore Gewessler,** *Federal Minister for Climate Action, Environment, Mobility, Innovation and Technology*
- **Günter Liebel,** *General Secretary, Federal Ministry of Agriculture, Forestry, Regions and Water Management*
- **Franz Titschenbacher,** *President ÖBMV & LK STMK*
- **Simone Schmiedtbauer**, *EU-Delegate*
- **Tobias Pröll**, BOKU
- **Franz Maier,** *Umweltdachverband*
- **Bernd Vogl,** *Klima- und Energiefonds*

12:30 - 13:30 **Lunch break & Poster presentation**




GLOCK

Mittwoch
18
Jänner

09:00–17:00 Uhr

1. Europäisches Pelletforum

Pelleteinsatz am Wärmemarkt – aktuelle Entwicklungen & Ausblick

Wednesday
18
January

09:00 am–05:00 pm

1st European Pellet Forum

Use of Pellets in the Heating Market – current developments & prospects

Wood pellets market in the Western Balkans: state and prospects for development

Prof. dr Branko Glavonjić
University of Belgrade-Faculty of Forestry
Kneza Višeslava 1, 11030 Belgrade
email: branko.glavonjic@sfb.bg.ac.rs
Homepage: *https://www.sfb.bg.ac.rs/branko-glavonjic/*

Wood pellet production in the Western Balkans continued to grow at double-digit growth rates. In 2021, 1.81 million tonnes were produced, which was 12.4% more than in the previous year. The popularity of wood pellets and the growth of its consumption led to to the growth of the number of producers. In 2021 there were 259 producers in the region, out of which 68 certified their production according to the EN plus certificate system. The number of the certified producers in 2021 increased by 7 compared to 2020 (EN plus, Bioenergy Europe, 2022).

As a result, the production of certified pellets increased. In 2021 it amounted to 1.27 million tonnes, i.e. 70.2% of the total production. Serbia maintained its leading position in the production of wood pellets in 2021 with a production of 470 thousand tonnes, while Croatia and Bosnia and Herzegovina took second and third place respectively .

The Western Balkans is a net exporter of wood pellets, since the exports from this region is almost three times larger than the corresponding imports. The export of pellets in 2021 amounted to 780 thousand tonnes and compared to 2020, it increased by only 7 thousand tonnes or 0.9%; 514 thousand tonnes were exported to countries outside the region, while the rest represented exports/imports within the region. The main exporting destination in 2021 was Italy, to which 467 thousand tonnes were exported, i.e. almost 60% of the total export. The largest exporters of wood pellets are Croatia and Slovenia, with a share of 46% and 26% in the total export of the region in 2021 respectively (UN Comtrade database, 2022).

The export/production ratio continued the decreasing trend from previous years and in 2021 it amounted to 43.2%. The largest quantities of produced wood pellets are consumed in the countries of the region. That consumption continued its growth trend in 2021, reaching the level of 1.42 million tonnes, which was 8.4% more than in 2020. Serbia has maintained its leading position in terms of pellet consumption with 497 thousand tonnes, and it is already certain that it will exceed 0.5 million tonnes in 2022. The second place is taken by Bosnia and Herzegovina with approximately 340 thousand tonnes.

The main characteristic of the pellet market in the Western Balkans in the first five months of 2022 has been the sharp increase in their prices. The energy crisis that affected all the countries of the region and the war in Ukraine were the main triggers of the accelerated price growth. The highest price increase was registered in Serbia. Average wood pellet prices in May 2022 were 75.5% higher compared to October 2021. In other countries of the region, the double-digit price growth was also registered in the observed period. The price growth in Bosnia and Herzegovina amounted to 72.9%, in Croatia 67.5% and in Slovenia 35.6%.

The Role of Primary Woody Biomass in EU Policies

Irene di Padua

Bioenergy Europe

Place du Champs de Mars 2, 1050 Ixelles, Bruxelles (BE)

dipadua@bioenergyeurope.org

www.bioenergyeurope.org

Co-Authors: Daniel Reinemann

Bioenergy is a vital part of the EU's renewable energy mix. In 2019, bioenergy represented 57,4% of the renewables consumed in the EU and 11,6% of its total energy, making it the largest EU indigenous source of energy. During this period of increasing uncertainty due to reliance on foreign fossil fuels, bioenergy stands as a clear counterpoint with over 96% of the biomass used for energy being produced domestically and the rest coming from trusted streams.

The new proposal in the European Parliament's Position on the revision of the Renewable Energy Directive (**REDIII**) would declare up to 35,7% of the biomass used for bioenergy as no longer sustainable and no longer eligible for receiving support (Article 29.1, Amendment 43).

Primary woody biomass is defined very broadly as "*all roundwood felled or otherwise harvested and removed. It comprises all wood obtained from removals, i.e., the quantities removed from forests, including wood recovered due to natural mortality and from felling and logging*…" While the legislation does include important exceptions such as "*woody biomass obtained from sustainable wildfire prevention measures in high-risk fire prone areas, woody biomass obtained from road safety measures, and woody biomass extracted from forests affected by natural disasters, active pests or diseases to prevent their spread*", this does not account for all the feedstock with no other commercial use than bioenergy or all the low-quality wood that should be removed to guarantee the health and productivity of forests.

Wood can be split, bent, rotten or too small for commercial use and therefore rejected by industries such as sawmills and pulp and paper ones, due to its low quality or contamination risks. The Renewable Energy Directive (REDII) already ensures the sustainability of biomass being used for bioenergy by guaranteeing that biodiversity is protected, and that carbon stocks are maintained or grown in accordance with the LULUCF Regulation. If this low-quality biomass is not used to produce bioenergy, then quantities greater than what are needed to protect biodiversity will be left to rot – thereby releasing the same carbon as with bioenergy use – or disposed of via open field burning, which does not generate an energy benefit, but results in substantial emissions which would be nearly zero in modern and efficient biomass boilers.

The report on the use of woody biomass for energy production in the EU (2021) by the Joint Research Centre (JRC) touches upon this timely discussion and opposes a blanket ban on using primary woody biomass for bioenergy: *"[…] It was concluded that, given the wide variety of situations across Member States, it was difficult to univocally define and meaningfully implement such restrictions in an EU legislation – the risk would have been to complicate compliance without necessarily fostering further sustainability or biodiversity conservation"* (JRC Report (2021), page 92). While the report does review the various feedstocks for woody biomass, it does not claim that secondary biomass is more sustainable than primary woody biomass.

Additionally, the differentiation between primary and secondary woody biomass is not a distinction commonly applied in industry because the end-use of the material is determined by its quality and here *primary* is not an indicator of quality. For this reason, there is very limited data on the share of primary versus secondary woody biomass that is used for bioenergy. If adopted, the restrictions proposed by the European Parliament would cause significant disturbances to the EU's energy market.

Given that 70% of the biomass used for bioenergy is woody biomass, restrictions on primary woody biomass would impact up to 35,7% of the feedstock for bioenergy. This means that up to 20,5% of the EU's renewable energy could be affected and some even declared unsustainable. These restrictions on primary woody biomass could jeopardise up to 4% of the total energy and potentially lead to bioenergy being forced out of the market at a time when energy prices are already rising and concerns about a cold winter ahead are already growing.

This would substantially decrease the EU's competitiveness, harm the economy, threaten jobs in rural areas, and put the EU's ambitious climate goals at risk.

09:00–12:30 Uhr

IEA AMF TCP Task 63:

Sustainable Aviation Fuels Nationale Strategien & Herausforderungen für die Markteinführung von SAFs

09:00 am–12:30 pm

IEA AMF TCP Task 63:

Sustainable Aviation Fuels – National strategies & challenges for the market uptake of SAFs

Mittwoch
18
Jänner

09:00–12:30 Uhr

IEA Cross TCP:

Wege zu einer flexiblen, sektorübergreifenden Energieversorgung mit besonderem Fokus auf die Flexibilitätsbereitstellung über den Wärmesektor

Wednesday
18
January

09:00 am–12:30 pm

IEA Cross TCP:

Towards a flexible, cross-sectoral energy supply with a special focus on flexibility provision via the heating sector

Wien Energie‘s vision of a sustainable energy and resource supply of Vienna

Teresa Schubert
Wien Energie GmbH
Thomas-Klestil-Platz 14, 1030 Wien, Austria
Teresa.schubert@wienenergie.at
www.wienenergie.at

Wien Energie is Austria’s leading energy supplier, providing 2 million people with power, gas and heating and cooling. Furthermore, Wien Energie processes 1 million tons of waste each year to generate electricity and heating energy for the district heating system, which warms 440.000 households in Vienna.
The City of Vienna and Wien Energie aim at being climate neutral by 2040. To reach this goal, electricity will represent the major energy source for mobility applications. Besides the increase of renewable electricity in the energy mix, which will be achieved by significant investments in wind, water and solar power as well as imports, the decarbonization of the heating sector represents one of the major challenges in the urban area. The implementation of heat pumps and the expansion of district heating will enable the provision of climate neutral heat for Vienna’s households, commerce and industry. To cover the heating energy demand of the district heating system, geothermal energy and large heat pumps to utilize waste heat from various sources play an important role. Nevertheless, certain amounts of flexible fuels in the climate neutral form of green gases will be necessary. The availability and utilization of green gases enables the flexible operation of the heating infrastructure in dependence of demand, for example to cover heating demands in cold winter times by peak load boilers.
The process pathway of gasification and subsequent synthesis represent an attractive option to produce green fuels by utilizing already available resource of the urban area, which are currently used to cover base-load heating demand. The conversion of waste streams with high heating value into storable fuels enables the flexibility provision of the energy system, but the necessary technology is not commercially available yet. To enhance the technology development, Wien Energie participates in research activities, led by BEST – Bioenergy and Sustainable Technologies GmbH, that demonstrate the conversion of waste fractions into syngas and green fuels. At the Wien Energie site Simmeringer Haide, the consortium operates a 1 MW dual-fluidized bed steam gasification plant to generate essential know how and data to scale-up and commercialize this technology as a relevant puzzle piece of the sustainable energy and resource system of Vienna.

Digitalization of energy management systems- optimization of internal energy use as an industrial company

Author: Ing. Maria Lechner MSc Ba
Organization: INNIO Jenbacher GmbH & CO OG
Address: Achenseestrasse 1-3, 6200 Jenbach
E-mail Address: maria.lechner@innio.com
Homepage: www.innio.com

During the last years a Microgrid in the INNIO360 Energy Lab in Jenbach has been established.
With the ability to simulate and verify all possible customer requirements under real market conditions, the INNIO360 Energy Lab demonstrates the energy turnaround at INNIO's site in Jenbach. The INNIO360 Energy lab increases the resilience, reduces the energy costs, and significantly reduces the carbon footprint of INNIO's production and office site in Jenbach by meeting the entire heat and power demand of the site production and offices throughout the year. The lab features a fully integrated onsite microgrid that combines photovoltaics (PV), battery storage, Jenbacher combined heat and power (CHP) solutions and an entire energy supply chain managed by our digital platform to build the energy systems of the future.

Overview on flexible bioenergy options and implementation

Daniela Thrän
DBFZ Deutsches Biomasseforschungszentrum GmbH
Torgauer Straße 116, 04347 Leipzig, Germany
daniela.thraen@ufz.de

Co-Authors: Elina Mäki, Nora Lange, Christiane Hennig, Uta Schmieder, Tilman Schildhauer, Jaap Kiel, Pieter Kroon, Fabian Schipfer, Amy Philbrook, Kjell Andersson, Cecilia Higa, Markus Gölles

Aim and approach

IEA Bioenergy TCP Task 44 *Flexible Bioenergy and System Integration* brings together experts with different backgrounds in the field of bioenergy from eight countries, Australia, Austria, Finland, Germany, Sweden, Switzerland, the Netherlands, and US, and from the European Commission. Task 44 contributes to the development and analysis of bioenergy solutions that can provide flexible resources for a low-carbon energy system. The objective is to improve understanding on the types, quality and status of flexible bioenergy, and identification of barriers and future development needs in the context of the entire energy system.

Task 44 started the analysis of flexible bioenergy in 2019-2021. It explored definition issues, technical and country implementation status, future expectations of stakeholders as well as policies supporting implementation. In addition to Task 44 experts, the broader IEA Bioenergy TCP network was engaged to exchange perceptions and knowledge on the potential contribution of bioenergy practices to the flexibilization of the energy system.

Scientific innovation and relevance

The ongoing energy transition is mainly driven by reductions in the cost of wind and solar energy, and political efforts to reduce greenhouse gas emissions. The increasing share of variable renewable energy (VRE) sources leads to a need for more flexibility and controllability of other energy sources, energy carriers and energy storage devices. The flexibility toolbox includes different measures, such as electricity storage in batteries, pumped hydro storage power plants, hydrogen based technologies, and sector coupling.

Bioenergy has features that can support the rapid transition to a low-carbon energy system by providing different system services, such as flexibility, balancing of VRE, decarbonization of hard-to-abate sectors, co-production of different products according to market demand, and negative emissions or carbon-neutral fuels, chemicals and materials via bioenergy carbon capture and storage or utilization (BECCS/U). Furthermore, bio-based value chains in connection to clean hydrogen can provide synergies for the system. However, provision of these services requires a fundamental shift in the way bioenergy is used and valorized in different systems.

While literature typically connects flexibility to short- and mid-term balancing services to the power grid, the flexibility services from bioenergy go beyond these. The long supply chains typically associated to provision of bioenergy or other bio-based products lead to multiple flexibilization options along the supply chains. Key barriers for wider implementation are rather related to market design than technical challenges or lack of example cases.

Results and conclusions

Task 44 provides an overview of technical options to provide flexibility in different categories along the bioenergy value chain (*feedstock*, *bioenergy carriers*, *operational* and *product flexibility*), implementation status of and support schemes for flexible bioenergy in eleven selected countries, future expert expectations towards flexible bioenergy, and first Best Practice examples. The collected information was condensed into a definition for flexible bioenergy to support understanding its multiple benefits. Further, five cornerstones that are required to enable market uptake and multiplication of flexible bioenergy solutions were elaborated.

In the presentation, we will summarize key findings from Task 44 by providing **a technical and market outlook** focusing on technical options for flexible bioenergy, barriers for implementation, and future opportunities and system services from bioenergy. Furthermore, we will present **five cornerstones** that are needed to accelerate the implementation of flexible bioenergy solutions.

Transformation of District Heating and Cooling Systems towards high share of renewables

Ingo Leusbrock, AEE - Institute for Sustainable Technologies
A-8200 Gleisdorf, Feldgasse 19, i.leusbrock@aee.at
www.aee-intec.at

Co-Authors:
Michael Salzmann, AEE - Institute for Sustainable Technologies, M.salzmann@aee.at
Thomas Pauschinger & Dr. Heiko Huther, AGFW - The German Energy Efficiency Association for Heating, Cooling and CHP, t.pauschinger@agfw.de & h.huther@agfw.de
Alice Dénarié, Politecnico di Milano, alice.denarie@polimi.it
Per Alex Soerensen, PlanEnergi, pas@planenergi.dk

Worldwide countries have defined ambitious targets for the reduction of greenhouse gas emissions and the transition of their energy systems. The present share of RES in DHC is estimated at 9 % worldwide [Werner 2017]. Recent studies and scenarios, however, expect a dynamic growth of RES in the DHC sector. Several countries introduced binding RES shares for DHC, in order to match their greenhouse gas targets. Reaching these objectives implies a strong increase of the share of renewable energy sources (RES) and efficiency technologies in the heat sector, combined with a reduction of the heat demand by building refurbishment. Here, district heating and cooling (DHC) plays an important role as an efficient and flexible, organizational and technical solution for the energy transition in the heat sector. DHC provides a broad platform for the integration of all kinds of RES. Moreover, it increases the overall efficiency of the energy system by enabling the use of combined heat and power (CHP) plants based on RES, the use of surplus heat from a variety of energy conversion or industrial processes as well as hybrid technologies for coupling the energy sectors. In particular, it enables relatively fast transition processes, also including the introduction of high shares of RES.

The integration of RES and in particular their combination with traditional DHC heat generation technologies require new and advanced technical and operational concepts, since:

- Heat sources with fluctuating production need to be integrated into DHC networks (solar thermal, RES P2H) as well as heat generators with operating times depending on the electricity market (CHP, P2H, heat pumps). Thus, the dynamic behaviour of heat generation and heat demand needs to be considered for suitable operation concepts.
- Heat stores need to be integrated for various purposes: short-term heat storage, peak shifting, long-term or seasonal storage of RES, flexible operation of multiple heat producers.
- DHC is often seen as cornerstone or energy hub for an overall integrated energy system. This hub function includes several challenges in the planning, operation and management of such a larger solution including DHC.
- The integration of RES heat sources and heat stores often requires an optimized design and operation of the whole DHC network and substations, as e.g. efficiencies depend on temperatures and hydraulics and as operating ranges of some technologies are limited.

The transition of DHC networks to RES technologies often requires extensive measures and high investments along the whole chain from the heat generation to the customer side. Transition processes are therefore on long term and need well-elaborated strategies and a thorough planning at all levels. Beside the technical solutions, the social and environmental impact of such transition processes are of importance. Stakeholders and public shall be engaged in the process and participation models are needed. In many countries, the regulatory frameworks for DHC are not yet adapted and suited to the use of RES and hinder their development in the DHC sector. Business and market models need to be developed, allowing a marketing of “green heat”, which is advantageous for both, heat supplier and customer.

In this talk, we will cover the technical and non-technical aspects enabling respectively currently limiting a large-scale roll-out of and transition to 100% renewable district heating and cooling. We will showcase examples and solutions from practice and discuss the role of DHC in the wider context of an integrated future energy system.

Opportunities offered by long-term heat storages and large-scale solar thermal systems

DI Dr. Viktor Unterberger
BEST – Bioenergy and Sustainable Technologies GmbH,
Inffeldgasse 21b, 8010 Graz
viktor.unterberger@best-research.eu
https://www.best-research.eu/

Heat is the largest energy end-use, accounting for 50% of global final energy consumption in 2018 and contributes to 40% of global carbon dioxide (CO2) emissions. Of the total heat produced, about 46% was consumed in buildings for space and water heating, at relatively low temperatures. Regarding the heat supply of buildings, district heating systems play an important role and are well-established in many countries since they typically enable an efficient resource utilization.

However, the heat for district heating networks in Europe and worldwide is still typically produced by caloric power plants driven by fossil fuels. Large-scale solar thermal systems provide a great opportunity to reduce the usage of fossil fuels and save CO2 emissions, especially when combined with long-term heat storages. In this context the number of large-scale solar thermal systems (>0.5 MW to GW) is steadily growing. This can be seen in the number of megawatt-scale systems for district heating and industrial applications. Twenty-three large-scale solar thermal systems with about 228,900 m² (160 MWth) were installed in Europe in 2019. It is expected that the trend of (very) largescale SDH systems will continue in the coming years and that these systems will become increasingly important for the decarbonization of the heat supply.

Large-scale systems combined with seasonal storages provides the opportunity that the solar fraction can be further increased from typically 20 % to 60 % or more. This is because in Europe, the demand for heat is usually around 10 times larger in winter than in summer, when solar irradiation reaches its peak. Between May and August, a solar field can meet all hot water needs, so that the district heating company operating the solar field can shut down boilers to significantly extend their useful lifetime. Seasonal storage can then store surplus energy from summer for use in winter and allows to store surplus heat available from other technologies.

Furthermore, the long-term heat storages can significantly contribute to an efficient operation of different sector coupling technologies, e.g. H2 production via electrolysis or CHP systems, since they allow to maximize the heat utilization and thus their overall performance. For this reason, long-term heat storages represent a very important component for a future, sustainable energy and resource system.
In the presentation, the current status regarding long-term seasonal storages together with large-scale solar thermal systems but also other technologies is outlined, their potential is discussed as well as interesting uses-cases will be shown. The main barriers utilizing the full potential and the interaction with other technologies and sectors will be discussed and an outlook given regarding which innovations and R&D is necessary to achieve this vision.

Possibilities through digitalization on the example of District Heating and Cooling

Dr. Dietrich Schmidt
Fraunhofer Institute for Energy Economics and Energy System Technology IEE
Joseph-Beuys-Strasse 8
34117 Kassel, Germany
Email: dietrich.schmidt@iee.fraunhofer.de
Homepage: www.iee.fraunhofer.de

Abstract

Digitalization or the wide implementation of digital technologies in our energy systems are believed to make our systems smarter, more efficient and reliable. Furthermore, a much higher integration of renewable energy sources into the systems is expected, as well as new business possibilities are generated by the use of innovative digital technologies and processes. In this context, the IEA DHC Annex TS4 project is aiming at promoting the opportunities of the integration of digital processes into DHC schemes. This implies the clarification of the role of digitalization for different parts within the operation and maintenance of the district heating and cooling system. Furthermore, the implementation of these technologies is going to be demonstrated in a close cooperation with a number of industry partners. Moreover, the challenges such as data security and privacy as well as questions about data ownership are also addressed.
Traditionally, district heating and cooling (DHC) networks are operated with a limited number of controls (as the control of the supply temperatures or the network pressure) to secure the required supply task and to optimize economics and ecologic performance. Detailed information of the supply and utilization structures (e.g. heat plant characteristics, power demand or time profiles) is not provided in classical network operation.
An optimized heat generation and overall network operation is possible with more information on the demand and flexibility options (storages) resulting in e.g. peak shaving and the reduction of expensive peak boiler use. In these systems a wider integration of fluctuating heat sources, such as solar thermal energy and power-to-heat applications operating on the electricity markets, can be shown in already realized projects. Wider implementation of information and communication technologies, as in many other industries, unlocks potentials for better network management based on real-time measurement data and the integration of new business models. A growing number of companies are offering products and services, as e.g. digital analyses platforms or smart meters, in this frame.
The current changes and developments in the operating environment are presenting both opportunities and threats for district heating providers. The main impact of the integration of digital technologies and methods for district heating providers is expected to be in the changing business environment. Via these new technologies the ways of working and using already established business models will change, new services and products will enter the market. On the other hand, existing business models are affected by the increased energy efficiency of the building stock caused by reduced heat sales and by the customer's demand for alternative heating solutions. Here digitalization will bring new methods to meet changing customer needs and to communicate with the different groups of customers.
The special importance of digitalization in district heating systems is that digitalization is a prerequisite in innovative low temperature, so-called 4th generation, heat networks to integrate renewable and fluctuating heat sources. So, digitalization has the potential to make heat networks more sustainable, more reliable, has the potential to integrate more renewable energy, more excess heat, better suitable for the integration of lower temperature levels e.g. via an optimal usage of heat pumps or CHP units, more profitable e.g. via the reduction of expensive fossil fuel consumption or via the reduction of transmission losses.
The presentation, the abstract presents and discusses the first results from the research work within the IEA DHC Annex TS4 on "Digitalisation of District Heating Systems – Optimised Operation and Maintenance of District Heating and Cooling Systems via Digital Process Management".

https://www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4

13:30–17:00 Uhr

BEST-Tag

Nachhaltige Bioraffinerien & Digitalisierung

01:30 pm–05:00 pm

BEST-Day

Sustainable biorefineries & digitalization

Learnings from Biomass combustion towards future bioenergy applications

Manuel Schwabl
BEST – Bioenergy and Sustainable Technologies GmbH
Gewerbepark Haag 3, 3250 Wieselburg
manuel.schwabl@best-research.eu
www.best-research.eu

Co-Authors: Elisabeth Wopienka

Biomass combustion has been a major source of renewable energy in Austria and all over the world. Since 2003 BEST (formerly known as Austrian Bioenergy Centre and Bioenergy2020+) contributed with R&D to developments of Austrian and European biomass combustion technologies, which have become world-leaders in the field of wood pellet, wood chips and log wood combustion. These developments have been made in several different dimensions: fundamentals in thermochemical-conversion processes, emission reduction by primary and secondary measures, methods for corrosion and slag formation monitoring, methods for real-life assessment and testing, energy systems and hybridisation as well as improved automation and modelling of the combustion systems. The major learnings are closely connected between each other:

- Combustion is a super-ordinate thermochemical conversion process, incorporating pyrolysis, gasification and oxidation reactions.
- User centric technology development. Conditions for future implementation must be considered already for development. In the past, developments were driven more towards fulfilling of standards and type testing requirements. Besides that, capabilities of the users in operation need to be considered also during an early stage.
- Social and environmental responsibility. Discussions about ambient air concentration of particulate matter or sustainability/CO2 neutrality of wooden biomass have shown, that the impact of the technology needs to be anticipated and treated with care.
- System compatibility. Bioenergy applications are only one gear-wheel in a bigger system. Technology combinations and hybridisations state the basis for a diverse and multi-adaptive bioenergy system.
- The USP in future renewable energy system. Renewable energy systems are highly diverse – every system has strengths and weaknesses. Depending on feedstocks, capacity and type of energy, bioenergy can provide substantial base load, reliable decentralized energy, high exergy applications, end/recycling of material cascading, co-production of valuable products (biochar)…

As a matter of fact, future bioenergy applications will benefit from these general learnings and will continue to pave the way for the European and Global energy transition.

GreenCarbon perspectives for regional sourcing and decarbonization

Elisabeth Wopienka
BEST – Bioenergy and Sustainable Technologies GmbH
Gewerbepark Haag 3, 3250 Wieselburg
elisabeth.wopienka@best-research.eu
www.best-research.eu

Co-Authors: Manuel Schwabl

The sustainable and economical use of available resources, decarbonization strategies in both raw material and energy supply and the creation of carbon sinks are the central challenges of our time. Material and energy cycles that are as regional as possible play a major role here. Thermochemical technologies` potential in the overall concept of the circular economy lies in particular in the upgrading of residues at the end of cascading usage paths, in the synergetic use of bioenergy contributing to sustainable energy supply concepts (e.g. energy storage, transition technology) and in opening up possibilities for decarbonization via the production of sustainable carbon products, closing the carbon cycle or creating carbon sink potentials.

R&D tasks of the Sub-area Thermochemical Technologies at BEST follow the vision of producing renewable carbon products – gas, bio-oil and coal – but also energy from renewable raw materials and residues, thus increasing the added value, contributing to security of supply and opening up opportunities for decarbonization. Guidelines for technology and processes development are environmental but also social aspects (e.g. air quality, circular economy principles, overall efficiency, regional value creation), the consideration of interaction with and interfaces to overall systems as well as aspects of user-centered development.

Technological focus in this regard is on pyrolysis and fixed-bed gasification technologies: A gasification test rig allows modular testing of new technologies and processes (e.g. oxygen-steam gasification), investigation and further development of methods for gas cleaning and post-treatment (e.g. tar cracking) as well as subsequent applications (e.g. gas burners) to be operated with product gas. The focus here is on options to replace natural gas, e.g. to provide high-temperature heat for industrial processes.

Investigations and further development in the field of pyrolysis aims at the production of renewable carbon products with defined properties for specific applications. The GreenCarbon Lab, currently under construction, offers the possibility to test different input materials and to produce renewable carbon products for different applications. Ongoing projects focus on the production of biochar for metallurgical processes, as material additives (e.g. for polymers or concrete) and for agricultural applications with the aim of nutrient and carbon recycling.

Bioconversion processes for renewable energy and/or biological carbon capture and utilisation

Bernhard Drosg
BEST – Bioenergy and Sustainable Technologies GmbH
Inffeldgasse 21b
8010 Graz
bernhard.drosg@best-research.eu
https://www.best-research.eu/
Co-Authors: Katharina Meixner, Lisa Bauer, Matthias Neubauer, Marceli Marzinsky, Werner Fuchs

The term “bioconversion” summarizes biotechnological processes where microbes are used as catalysts for the desired conversion process. This contribution gives an overview of the different aspects on how microbes can be used to valorize biomass (e.g. residues, by-products) or carbon-rich gases (CO2, flue gas, syngas). The products range from energy carriers (biogas, bio-methane, bio-hydrogen, etc.) to chemicals (volatile fatty acids, alcohols), bio-polymers and high value products (e.g. microalgae biomass, pigments). Current research trends aim at replacing traditional C-sources such as sugars by organic wastes and CO_2. In addition, some processes target at biological carbon capture and utilization (bio-CCU) where CO_2 off-gases are converted to products rather than directly emitted to the atmosphere. To reach these goals a large variety of bioconversion processes can be applied: anaerobic digestion, anaerobic acidification, dark fermentation, gas fermentation and photo-autotrophic microalgae processes.

Utilization of syngas for the production of fuel and chemicals – recent developments and outlook

Gerald Weber
BEST – Bioenergy and Sustainable Technologies GmbH
Mariahilfer Straße 51/1/15a, 1060 Vienna, Austria
gerald.weber@best-research.eu
www.best-research.eu

The production of synthesis gas (syngas) from renewable sources is considered as one of the key technologies for a sustainable energy and material cycle. Syngas represents a valuable intermediate product, which can be used for the production of fuel and input material for the chemical industry. The main route for the production is the process of gasification. The steam blown Dual Fluidized Bed (DFB) gasification technology allows the provision of a hydrogen-rich raw syngas. A relatively new way for the production of syngas represents the solid oxide electrolyser (co-SOEC). DFB gasification as well as co-SOEC have in common that the process temperatures are in between 800-900°C and carbon is converted via the reaction with steam to hydrogen and carbon monoxide. The raw syngas from gasification (so called product gas) has to be cleaned to purity levels, which are required in the subsequent syngas process step. In a first stage the gas is cleaned from particles, tar compounds as well as from hydrochloric acid and ammonia in a coarse gas cleaning section consisting of heat exchanger, filter, quench and biodiesel scrubber. In the fine gas cleaning section, a second biodiesel scrubber, water scrubber, activated carbon and zinc oxide are used to obtain the demanded purity level for the synthesis step (especially sulphur removal).

Past research activities of BEST GmbH and TU Wien have been focused on the improvement of the gas cleaning section (to reach the purity levels), to develop processes for the syngas conversion e.g. as Fischer-Tropsch (FT) and mixed alcohols synthesis as well as to upgrade the obtained products for their application as fuel and/or chemical (e.g. FT-waxes for pharmacy). A slip stream of the raw syngas of the commercial DFB gasifier in Güssing was used over years for the further development of these technologies. In the field of FT synthesis, a Slurry Bubble Column Reactor (SBCR) is used for the conversion step. The good mixing behaviour in a SBCR is responsible for high CO conversion rates as well as high thermal transfer rates achieving isothermal conditions along the reactor. In 2016 this SBCR technology was further scaled-up to pilot scale obtaining one barrel (~159 litre) per day of FT products. In the field of mixed alcohol synthesis, a simple gas cleaning section (comprising mainly of gas scrubbers and/or steam reforming unit) and a fixed-bed synthesis reactor were used as experimental setup to provide a product mixture consisting of methanol, ethanol and propanol.

In Vienna, a biorefinery for the conversion of biogenic residues and waste materials is currently being established on a demonstration scale. An advanced reactor design for the DFB process with a capacity of 1 MW was implemented. The reactor design is based on a 100-kW pilot plant at the TU Wien, where experimental studies have shown increased fuel conversion, lower tar levels in the syngas, and subsequently better overall performance, especially in the conversion of biogenic residues and waste materials. The 1 MW DFB gasifier is the key part of the Syngas Platform Vienna, which consists of a complete process chain combining gas generation from waste with a downstream FT synthesis pilot plant. In addition, a partial stream of the syngas will be used in a connected laboratory for research in advanced gas purification, biological gas upgrading and sustainable hydrogen production.

Future activities at the Syngas Platform Vienna in the field of fine gas cleaning are focused on the economic optimization of the gas cleaning and their adaption for the usage of low-quality fuels with a higher level of impurities. The usage of residues and wastes increases the economics of the biorefinery process. An upcoming COMET project is focused to combine the gasification of residues, FT synthesis and alcohol synthesis in one project to prepare the basis for the roll out of Sustainable Aviation Fuels (SAF). The by-products e.g. olefins, waxes and alcohols can be used as feedstock in the chemical industry sector and can therefor further increase the profitability of the overall process chain. Research activities within this project are focused on the usage of residues, wastes and CO_2 as feedstock. Furthermore, high valuable knowledge with the SBCR FT pilot unit should be gathered to allow a further upscaling of the technology.

Evaluation of different numerical models for the prediction of NOx emissions of small-scale biomass boilers

Michael Eßl
BEST research GmbH
Inffeldgasse 21b, 8010 Graz, Austria
michael.essl@best-research.eu
www.best-research.eu
Co-Authors: Kai Schulze, Robert Scharler, Andrés Anca-Couce

The increasing demand for sustainably cultivated biomass to generate heat is particularly concerning in small-scale furnaces and residential application. This work investigates a small-scale biomass boiler that utilizes an under-feed stoker concept with double air staging and softwood pellets as fuel. The goal of the studies is to optimize the boiler in terms of NO_x emissions with numerical methods. CFD methods are already well established in science and industry and provide a detailed insight. However, they are very time consuming, when conducted on a full-scale 3D model, which limits the number of parameter variations. Therefore, this work investigates CFD as well as reaction kinetic studies with ideal reactors. The reaction kinetic studies are computationally inexpensive compared to CFD, therefore allowing the variation of multiple parameters. The numerical studies are conducted with three different methods of varying complexity: (i) a reactor network of zero-dimensional continuously stirred tank reactors (CSTR), (ii) a reactor network of one-dimensional plug flow reactors (PFR) and (iii) a full-scale 3D CFD simulation. For the CFD method an in-house developed 3D packed bed model for biomass grate furnaces has been expanded and improved to consider the release of NO_x precursors at the particle level. For the CSTR and PFR methods the fuel bed is not explicitly modelled, but rather the composition above the fuel bed from CFD is taken as inlet composition for the reactors that model the secondary and tertiary combustion zone. All methods employ an up to date skeletal reaction mechanism from literature (37 species, 168 reactions) that includes hydrocarbon as well as nitrogen chemistry. The CSTR and PFR method are compared with the CFD method and also benchmarked against experimental data. The species composition and especially the NO_x-emissions of the flue gas at the boiler outlet is selected as the benchmark variable. The reactor network methods showed reasonable agreement with the CFD results as well as experimental data and give valuable indications for emission reductions, depending on the mixing behaviour in the combustion chamber. With the computationally inexpensive methods multiple parameter variations e.g. air-to-fuel ratio, residence time, temperature, are run in a fraction of the time of a CFD analysis. Therefore, the CSTR and PFR method can be applied in an early stage of development, in order to derive design guidelines faster and speed up optimization of the boiler. Furthermore, the CSTR and PFR method support the selection of operating conditions to perform final CFD-based optimisations.

Digitalization as the basis for the efficient and flexible operation of renewable energy technologies

Markus Gölles
BEST – Bioenergy and Sustainable Technologies GmbH,
Inffeldgasse 21b, 8010 Graz
markus.goelles@best-research.eu
https://www.best-research.eu/

To achieve a sustainable energy and resource supply many different technologies need to work together appropriately as efficient, flexible and automated as possible. However, many hurdles still must be overcome on this path, the legislative basis needs to be adjusted, markets need to be established, but also many technical problems need to be accomplished. To make it even more difficult, all this must be carried out in very limited time and with limited personnel resources.

Digitalization can play a key role in this, since it allows a significant increase in the degree of automation of the different processes, i.e. the conception, detailed design and operation of these more and more complex systems. With this increased degree of automation, many processes can be standardized and thus become more efficient, and more sophisticated methods can be applied.

In any case, a first hurdle in the process is that many plants, systems, processes still lack a high degree of digitalization, e.g. in most plants as few sensors as possible are installed and only a small amount of data (or even no data) is recorded to keep the investment costs (CAPEX) as low as possible, since the achievable savings of the operational costs (OPEX) would not exceed them. This of course strongly limits the methods which can be applied for a highly automated and efficient operation. However, with increasing complexity of the systems and the need of more flexible technologies and components the situation is changing, more powerful methods will simply be required, and this automatically requires also more digitalization.

In this context, this presentation will focus on the possibilities evolving from an increased degree of digitalization for the operational management of renewable energy and resource systems. In general, 3 possibilities can be distinguished: i) advanced control concepts can get applied for the control of the different technologies, aiming for an operation at highest efficiency in all operating points, and high flexibility in terms of modulation capability and input streams used, e.g. in case of conversion technologies for biogenic resources; ii) advanced methods for the overall coordination of the different technologies, storages, etc., aiming for an optimal interaction at any time, taking knowledge on the strengths and weaknesses of the different technologies, their current status and any available information on the future conditions (weather conditions, demand, etc.) automatically into account; iii) a variety of new digital services to simplify operational management, e.g. for the on-line diagnosis of the systems, continuously providing a deep insight in the current status of the system (advanced monitoring) and helpful information regarding maintenance already in advance (predictive maintenance).

Based on an analysis of the current status, the presentation will elaborate the different possibilities for an improved operational management of renewable energy and resource systems on the basis of several practical examples, such as a municipal solid waste incineration plant, a biomass gasification CHP system, or interconnected, cross-ownership district heating grids.

Smart Control for Coupled District Heating Networks

Valentin Kaisermayer
BEST - Bioenergy and Sustainable Technologies GmbH
Inffeldgasse 21b/I, 8010 Graz, Austria
valentin.kaisermayer@best-research.eu
https://best-research.eu/

Co-Authors: Daniel Muschick, Markus Gölles, Martin Horn

District heating (DH) networks will play an important role in transitioning into a carbon natural economy. When communities grow, so do the respective DH networks, and often the opportunity for coupling different DH networks together arises. This creates the need for high-level control concepts that allow for the handling of such coupled DH networks. These networks are often operated by different owners with different economic interests. Any high-level control concept for coupled DH networks must respect this multi-owner energy system structure.

Optimization-based energy management systems (EMS) are a promising high-level control approach for coupled DH networks. These rely on mathematical optimization to devise an optimal operation plan for all production units, taking varying prices, future demand and yield predictions, and operational constraints into account. However, extending an optimization-based EMS for coupled DH networks with a multi-owner structure is non-trivial. This contribution aims to provide an EMS algorithm that supports this task.

The presented concepts were tested on the real-world example of the three DH networks of Leibnitz, Austria. The three DH networks are operated by two owners and incorporate biomass boilers (3,2MW and 2,4 MW), industrial waste heat (~6MW) and a gas backup boiler (8MW). The annual heat demand of the three networks ranges from ~4GWh to ~14GWh. The two networks that are operated by the same owner are directly hydraulically connected and the third one is connected via a bidirectional heat transfer station (4MW). However, during the test runs the full transfer capacity could not be reached since the pressure conditions did not allow it. The temperatures in all three networks are similar, making heat exchange easier. The goal was to reduce the overall cost and CO2 emissions of the energy system. Preliminary test results show that the proposed control concept is able to achieve a reduction in CO2 emissions by 35% and a reduction in fuel costs by 7%.

Integrated energy solutions for a decentral energy future – challenges and solutions

Armin Cosic, DI
BEST - Bioenergy and Sustainable Technologies GmbH
Gewerbepark Haag 3, 3250 Wieselburg-Land
armin.cosic@best-research.eu
https://www.best-research.eu/de/kompetenzbereiche/microgrids/allgemeine_informationen

DI (FH) Stefan Aigenbauer, DI Nikolaus Houben, DI Christian Oberbauer, Michael Zellinger MSc, Dr. Muhammad Mansoor, Dr. Michael Stadler

The planning and design of Microgrids and renewable based energy communities are mostly based on individual research projects, which do not produce standardized solutions and are therefore time consuming and expensive. We present the OptEnGrid planning tool, which mathematically optimizes decentralized energy technologies as batteries or electric vehicles in terms of optimal technology portfolio investments, capacities, and deployment in a new standardized and repeatable way. The planning is carried out according to economic and/or ecological criteria based on Mixed-Integer Linear Programming (MILP) optimization. The mathematical setup allows the user to model cross-sectoral energy systems (electricity, heating, cooling, hydrogen) as well as Microgrids with multiple nodes (e.g., buildings). On the other hand, supervisory control systems are needed to dispatch the installed distributed energy resources (DER) assets in an optimal way. The BEST's Smart- and Microgrids (SMG) controller is responsible for the operational optimization of different DERs and their coordinated real-time operation. The modelling framework for the microgrid supervisory controller is based on OptEnGrid's mathematical formulation and algorithms. To test the planning and control algorithms, we established a Microgrid testbed in Wieselburg, Lower Austria, which focuses on data collection for the heating and electric users and generators for two connected buildings (firefighter house and office building). The electric technologies are controlled via our centralized MILP Model Predictive Control (MPC) algorithm. In the future also thermal assets will be controlled.
In this presentation we discuss real use cases, and the modelling needs for the actual discussed energy communities in Austria. We will present the methodology behind OptEnGrid, discuss the MPC, which controls the Microgrid Testlab in Wieselburg. To be able to deploy such Microgrid MPC's it is important to overcome integration challenges. The research work has shown that the communication between different assets can be a challenge. Almost every technology vendor uses its own data formats and sometimes limits access to the technology. Thus, we also focus a lot on ways to overcome these integration challenges via our own efficient solutions (e.g., with Raspberry PIs). Finally, to successfully predict real-time operation, effective output forecasting for e.g., PV, in combination with reliable load forecasting is needed. We will also discuss those Artificial Intelligence enabled forecasting techniques.
The results from the Microgrid Testlab in Wieselburg show energy cost reductions of 40% as well as CO_2 reduction potentials of 60%. The optimal investment capacities for the lab are a 74 kW PV system, 60 kWh battery system, 420 kW_{th} biomass system, hot water storage system with 9400 L, absorption cooling system with 80 kW_{th}, cold storage with 3200 L, and a conventional cooling system with 232 kW_{th}. Because of the battery system and the optimized dispatch with the MPC controller 97% of the local generated electricity is used internally.

Wood-Value-Tool: Techno-economic assessment of the forest-based sector in Austria

Marilene Fuhrmann
BEST – Bioenergy and Sustainable Technologies GmbH
Inffeldgasse 21b, A-8010 Graz
marilene.fuhrmann@best-research.eu
www.best-research.eu

Co-Authors: Christoph Strasser, Christa Dißauer

EU and national policies promote the use of biomass for material and energy purposes to foster a transition towards a sustainable bioeconomy. This transition will rely to a large extent on the advancement in technology of a range of processes, on cost competitiveness, on the achievement of breakthrough in terms of technical performances and will depend on the availability of sustainable biomass. European forest-based industries and wood markets will take a crucial role in this transition, but are confronted with several challenges in tackling the economic, pandemic and climate crises.

A tool for techno-economic assessments based on predefined building blocks was developed to provide a basis for taking strategic decisions on whether and how to increase the value added in woody biomass utilization: the “Wood-Value-Tool”. This user-friendly Excel-calculation tool was developed within the project BioEcon at BEST – Bioenergy and Sustainable Technologies GmbH. It allows to specify selected processes in terms of technical parameters, like production capacity, operating hours, lifetime, as well as predefined input materials (roundwood, semi-finished products, by-products, residues etc.).

The techno-economic assessment covers investment, operating and raw material costs, expected product price, revenues, gross profit and specific production costs as well as mass and energy balances. Currently the following processes for material and energy provision are included:

<u>Material</u>
- Wood supply
- Pulp production (incl. Lignin and Hemicellulose extraction)
- Paper production
- Regenerated cellulose fiber production
- Sawmill
- Particleboard production

<u>Energy</u>
- Combined heat and power (CHP)
- District heating plant
- Pellets production
- Wood gasification + BioSNG synthesis
- Wood gasification + FT synthesis
- Flash pyrolysis

In a next step, further functions will be integrated in the “Wood-Value-Tool”, taking macro- and socio-economic as well as sustainability criteria into account, such as CO_2-equivalent emission calculations. The advanced tool is intended to provide support for sustainable biomass utilization in different industries, based on environmental, economic and social criteria. Its application has therefore the potential for optimizing woody biomass utilization in accordance with all three dimensions of sustainability.

Donnerstag
19
Jänner

09:00–10:30 Uhr

Parallelblock 1

Nachhaltigkeit des Einsatzes von Biomasse für die energetische Nutzung

Thursday
19
January

09:00 am–10:30 am

Parallel session 1

Sustainability of biomass for energy solutions

Nachhaltigkeitsbewertung einer klimaoptimalen Wald- und Holznutzung

Autoren: Prof. Dr. Hubert Röder, MSc. Stefan Füchsl

Professur für Nachhaltige Betriebswirtschaft, Hochschule für angewandte Wissenschaft Weihenstephan-Triesdorf am TUM Campus Straubing für Biotechnologie und Nachhaltigkeit, Am Essigberg 3, 94315 Straubing, Deutschland

Email: hubert.roeder@hswt.de; stefanfuechsl@hswt.de

Homepage: sbe.cs.tum.de

Abstract

Die klimaoptimale Nutzung von Wäldern ist ein in Europa kontrovers diskutiertes Thema. Im Fokus steht dabei die Frage, ob die Stilllegung von Wäldern und der Aufbau hoher Vorräte und Totholzanteile mit hoher Biodiversität oder ein aktiver Waldumbau zu artenreichen, zuwachsstarken und klimaresilienten Mischbeständen mit Holzproduktspeichern und Substitutionseffekten die optimalere Strategie für einen Beitrag zur Reduktion von Treibhausgas (THG)-Emissionen ist. Dieser Vortrag stellt erstmalig die Ergebnisse ökobilanzierungsbasierter Analysen zur Beantwortung auf diese Frage vor. Zu diesem Zweck wurde eine sektorenübergreifende THG Bilanzierung vorgenommen, die sowohl das System Wald (LULUCF), als auch mögliche Nutzungspfade von Holz einbezieht. Damit werden Senken-, Speicher-, und Substitutionsleistungen beachtet und dabei vergleichbare und umfassende Systemgrenzen verwendet. Zusätzlich werden zwischen fossilem und biogenem Kohlenstoff unterschieden und Effekte auf die Biodiversität im Wald berücksichtigt. Durch definierte Nutzungsszenarien und eine Betrachtung der bisherigen historischen Entwicklung der Wälder in Europa und der Holznutzung wird die kurz und langfristige Klimawirkung von Nutzungseinschränkungen oder -steigerungen auf verschiedenen Ebenen aufgezeigt. Sie zeigen auf, dass eine steigende stoffliche Nutzung von Holz in langlebigen Produkten und die Investition in moderne Formen der Holzenergie auf der Basis der entstehenden Nebenprodukte und Restholz-Sortimente einen zusätzlichen langfristigen THG-Speicher erzeugen und THG intensivere Produkte und Energieträger vermeiden werden. Gleichzeitig wird durch die Nutzung vor allem älterer Nadelwälder die Klimaresilienz, die Zuwächse und damit die laufende Aufnahme von Kohlenstoff aus der Atmosphäre gesteigert und die Biodiversität in den entstehenden Mischwäldern nimmt deutlich zu. Diese Szenarien wurden bisher bei der Diskussion über die klimaoptimale Behandlung der Wälder und Förderung der Bioenergie in Europa nicht ausreichend berücksichtigt und stellen wesentliche Diskussionsbeiträge zur Ausgestaltung klimaoptimaler Maßnahmen zur Erreichung der EU Klimaschutzziele, Biodiversitätsziele und zur Versorgung einer holzbasierten Bioökonomie in Europa, Deutschland und Österreich dar.

Themenbereich: Carbon Neutrality 2050; Forest based Bioeconomy; Forest based Biodiversity; Primary Biomass for Bioenergy; Bioenergy Carbon Capture and Storage - BECCS; Negative Emission Technologies - NET.

Klimaschutz und Forstwirtschaft
Climate Mitigation and Forestry

E.D. Schulze
Max-Planck Institut für Biogeochemie
Postfach 100164
07701 Jena, Deutschland
dschulze@bgc-jena.mpg.de

The present public debate considers an increase in wood biomass by protection from management as the main mechanism of climate mitigation by forests.
In my contribution I will show that storage of biomass is not the only mechanism to mitigate climate change, and I will point at obstacles that hinder the recognition of forest management in this process

1. Managed and unmanaged forests do not differ with respect to ecosystem fluxes. Wood extraction does not lower productivity.
2. The carbon balance of forests is dependent on the amount of living biomass. Forests with standing biomass of >500 m^3/ha appear to become a carbon source.
3. The maximum biomass in managed forests at the time of final harvest is equal to the biomass in un-managed forests. There is no carbon debt. The extracted biomass is mainly stored and recycled in products of variable time-in-use. Thus, the carbon store for climate mitigation is the sum of standing biomass plus the storage in products
4. Over the life time of spruce and beech in unmanaged conditions, there are about 3 to 4 life-cycles of trees under management, which are the basis for maintaining the product pool.
5. IPCC offers the accounting of products, but as default, harvest is accounted as immediate emission, independent of the life-cycle of products. This hinders the recognition of the forest service to supply wood for commodities and energy to the public.
6. The use of old or new biomass for bioenergy is not accountable, even though the use for energy is the ultimate process also for products, and only the energy use replaces fossil fuels. It is the energy sector and not forestry that gets the credits for reducing fossil fuel use.
7. With ongoing climate change, in-situ storage of biomass emerges as risky and non-permanent. It is only by management that climate is mitigated via reducing fossil fuel consumption.

Integrated Assessment Framework for Low iLUC Risk Certification

Beike Sumfleth
DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Straße 116, 04347 Leipzig, Germany
beike.sumfleth@dbfz.de
https://www.dbfz.de/

Co-Authors: Stefan Majer, Daniela Thrän

Background

Indirect land use change (iLUC) is considered a significant challenge associated with an increasing demand for biomass and bioenergy. Certification of biobased products is discussed as one potential way to manage this risk. Thus, an approach has gained relevance, with the aim of certifying biomass with low iLUC risk. However, extending existing certification schemes towards a credible and reliable certification approach to account for iLUC is still an open question.

Aim and contribution to the European Green Deal

The work presented here aims to develop an integrated assessment framework for low iLUC risk certification of biobased products. The development of such a certification instrument could help to reduce GHG emissions of biobased products attributable to iLUC and thus support the decarbonization of the EU energy system. It could promote the decoupling of an increased use of feedstocks for bioenergy from the limited resource of land. Finally, developing such an approach could ensure food security by reducing global land demand for bioenergy purposes.

We present the methodological approach, results, and conclusions of the project to date. Finally, we give an outlook on the next steps and research demand.

Methodological approach

To achieve this aim, we apply a methodological approach based on (1) a review of low iLUC risk certification practices with a particular focus on practices that could be used to reduce the iLUC risk of an individual biomass producer, so-called additionality practices, (2) an inventory of potential trade-offs that could arise from the application of such practices to conduct a gap analysis comparing whether recognized voluntary certification schemes take such trade-offs into account, and (3) the development of a knowledge base for decision-making on methods that could be used to assess the identified trade-offs in sustainability certification.

Results and conclusions

We reviewed five additionality practices and also some potential methods for verifying them. These practices could be adopted by an individual biomass producer to reduce iLUC risks by increasing relative resource efficiency and providing an amount of biomass in addition to a reference case.

characterized by the use of practices that an individual producer can adopt and that aim to reduce iLUC risks by increasing relative efficiency and providing an amount of biomass additionally to a reference case.

With the gap analysis, we found that certain trade-offs are given preferential consideration by certification schemes, e.g., biodiversity loss, and that there are significant gaps in certain trade-offs, e.g., resource depletion. In addition, we found that the cultivation of biomass on unused land is the most promising additionality practice in terms of addressing trade-offs.

Outlook

Based on the findings to date, in the next study we will develop a knowledge base for decision making on assessment methods for trade-offs in low iLUC risk certification. Such a knowledge base intends to support voluntary certification schemes in their decision to implement a specific assessment method for a specific trade-off. In doing so, we seek to contribute, among other things, to the identification of best practice methods for the assessment of trade-offs studied for the certification of biobased products.

Environmental and social impacts of biofuel production using waste wood integrated in a large-scale steel mill

Maria Hingsamer *maria.hingsamer@joanneum.at,*
Michael Brenner-Fließer *michael.brenner-fliesser@joanneum.at;*
Ingrid Kaltenegger *ingrid.kaltenegger@joanneum.at*
JOANNEUM RESEARCH Forschungsgesellschaft
mbH
Waagner-Biro-Straße 100, 8020 Graz, Austria
www.joanneum.at/life
Markus Hadler *UNIVERSITY OF GRAZ*
Universitätsstraße 15, 8010 Graz, Austria
Markus.hadler@uni-graz.at; www.uni-graz.at
Wim Van der Stricht
ARCELORMITTAL BELGIUM, ArcelorMittal CTO Technology Strategy
John-Kennedylaan 51, 9042 Gent, Belgium
wim.vanderstricht@arcelormittal.com, www.arcelormittal.com

Subject area: Sustainability and politics

Within the H2020 project TORERO (TORefying wood with Ethanol as a Renewable Output: large-scale demonstration), a cost-, resource-, and energy-efficient technology concept for producing bioethanol from a wood waste feedstock, fully integrated in a large-scale, industrially functional steel mill will be demonstrated. Wood waste is converted to biocoal by torrefaction, biocoal replaces fossil powdered coal in a steel mill blast furnace, carbon monoxide in blast furnace exhaust fumes is microbially fermented to bioethanol, while material and energy loops of the process are closed to a very large degree. This project creates a value chain for wood waste, which currently has no attractive application. TORERO is an add-on technology that can be used to upgrade existing facilities of the steel sector, an industry that is actively scouting for technological solutions to make its production processes more sustainable. This contribution wants to present the method used to measure this sustainability by calculating environmental as well as social changes provoked by this system changes. To do so, an environmental and social lifecycle assessment (LCA and s-LCA) is performed. Results of the assessment of environmental and social impacts will be presented. To assess the sustainability along the whole value chain, life cycle-based methodologies have been developed over the last years. LCA considers environmental impacts along supply chains, from extraction of raw materials to end-of-life of products. The aim of this paper is to describe the use of LCA and s-LCA to assess the environmental and social impacts of the use of waste wood for energy production. Important methodological aspects and results of the integrated TORERO process are presented. The key environmental impacts for the assessment (e.g. GHG emissions, GHG emission reduction potential, primary energy demand) are quantified and compared with LCA of conventional reference products. Furthermore, alternative uses of waste wood and the actual situation are included in the assessment. Simultaneously, a social Life Cycle Assessment (s-LCA), following the UNEP/SETAC-guidelines (UNEP/SETAC, 2020) will measure the expected social impacts with regards to key stakeholders (workers, local community, society). Categories in which the most severe impacts can be expected (social hotspots) are determined by using the Social Hotspot Database.
Based on the needs of the waste wood sector and the integration in an existing infrastructure the methodologies are adapted to the specific challenges and framework conditions thereby demonstrating a standardized procedure to measure sustainability in large industrial productions, which is scalable. An important aspect in the LCA is the allocation of biogenic carbon of the waste wood to the different resulting products. For assessing the environmental impacts of TORERO process chain, it is relevant to consider the following important aspects: inclusion of the whole value chain of the waste wood input; the allocation of the biogenic carbon to the different products; avoiding double counting benefit and product use of carbon; distinguishing between the different sources of carbon – fossil and biogenic - for understanding the carbon cycle and effects on global warming; including the current use of waste wood; and comparing the environmental impacts to the actual situation to get a complete picture on the environmental impacts of waste wood use. First results in terms of social impacts show advantages for the new system, especially in the categories of labour rights and governance and emphasizes the importance of considering substitution processes related to the process chain.
Acknowledgement: TORERO has received funding from the European Union's Horizon 2020 - Research and Innovation Framework Programme (H2020-EU.3.3.3. - Alternative fuels and mobile energy sources). Project ID: 745810.

Practical experiences from the implementation of the RED II

Amparo Arellano
Sustainable Resources Verification Scheme (SURE)
Schwertberger Str. 16, 53177 Bonn (Germany)
a.arellano@sure-system.org
https://sure-system.org/en/

Abstract:

In a world where the pressure on the natural resources is ever increasing and where the global temperatures continue rising, the need to replace fossil fuels for renewable energy sources is imperative. With the establishment of the EU Renewable Energies Directive 2018/2001 (RED II) Europe has taken a leading position globally towards increasing the share of green energies and reducing greenhouse gas emissions. Sustainable Resources Verification Scheme (SURE) certification was founded in 2019 with the aim of to promoting the use of sustainable biomass for bioenergy production and to provide a robust certification scheme for demonstrating compliance with the sustainability criteria under RED II.

During this session we will be sharing practical experiences from the implementation of RED II and the experience of the development of SURE certification across Europe since 2019, as well as the lessons learned along the way.

In this session we will showcase – through practical examples - how SURE certification offers a pragmatic solution for operators all across Europe, where our scheme requirements are built on the existing companies' systems and processes, with the objective of streamlining efforts by operators and avoiding redundancies.

At SURE we understand the challenges faced by biomass operators, given the continuous changes in EU legislation and the ambitious timelines for implementation which often times create bottle necks and barriers for the industry.

With over 2500 valid certificates for sustainable biomass and many more on the way, we expect SURE scheme to continue growing at a strong pace in 2023, and believe our journey so far can be of interest to other stakeholders in the biomass sector wishing to learn about RED II and its implementation on the ground.

09:00–10:30 Uhr

Parallelblock 2

Biochemische Bioraffinerien

09:00 am–10:30 am

Parallel session 2

Biochemical Biorefineries

SynGas-Fermentation zur Erzeugung von Treibstoffen und Chemikalien aus organischen Reststoffen

Werner Fuchs, Clemens Hiebl
Universität für Bodenkultur Wien, Dept. IFA-Tulln, Institut für Umweltbiotechnologie
Konrad Lorenz Straße 20, A-3430 Tulln
werner.fuchs@boku.ac.at
https://boku.ac.at/ifa-tulln/institut-fuer-umweltbiotechnologie

Bernhard Drosg, Marceli Marzynski,
BEST - Bioenergy and Sustainable Technologies GmbH
Inffeldgasse 21b, A-8010 Graz
bernhard.drosg@best-research.eu
https://best-research.eu

Organische Materialien können unter Luftabschluss durch Erhitzen vergast werden. Das entstehende Gemisch aus Kohlendioxid (CO_2), Kohlenmonoxid (CO) und Wasserstoff (H_2) wird als Syn(these)gas bezeichnet. Mit Hilfe von Mikroorganismen können in einer nachfolgenden Fermentation die gasförmigen Ausgangsstoffe in unterschiedliche Produkte, z.B. organische Säuren oder Alkohole, umgewandelt werden. Die eingesetzten Mikroorganismen, werden der Gruppe der Aceto- oder Methanogenen zugerechnet. Sie verwerten die Gase im Zuge ihres Energiestoffwechsels und schleusen die gebildeten Produkte in das umgebende Medium aus. Die Fermentationsprodukte bilden die Ausgangsbasis zur Erzeugung nachhaltiger Treibstoffe und Chemikalien.

Zu den möglichen Ausgangsmaterialien gehören verschiedene Abfallströme wie etwa Holzreste, landwirtschaftliche Nebenprodukte oder Hausmüll. Auf diese Weise können Abfälle, die sonst nur eingeschränkt nutzbar wären, in den Stoffkreislauf zurückgeführt werden. Wesentlicher Vorteil des Verfahrens ist die hohe Anpassungsfähigkeit von Mikroorganismen an unterschiedliche Gaszusammensetzungen, woraus sich eine hohe Variabilität bei den einsetzbaren Reststoffen ergibt.

Die Erzeugung von Methan (CH_4) oder Ethanol als Biotreibstoffe ist bereits als Stand der Technik zu bezeichnen. Zur Zeit wird intensiv an weiteren mikrobiologischen Umsetzungsreaktion geforscht, mit denen die Palette der gewonnen Chemikalien verbreitert werden soll.

Am Institut für Umweltbiotechnologie wird vor allem der Einsatz synthetischer Mischkulturen, die in synergistische Weise bei der Produktion hochwertiger Metaboliten zusammenwirken, untersucht. Mischkulturen zeichnen sich gegenüber Reinkulturen, welche nur einen einzelnen Stamm an Mikroorganismen beinhalten, durch ihre hohe Robustheit und Flexibilität aus. Die eingesetzten künstlich zusammengesetzten Kulturen bestehen aus Organismen, die die gasförmigen Substrate in Acetat und Ethanol umsetzen (*Clostridium carboxidivorans, C. ljungdahlii, Alkalibaculum bacchi*) und weiteren Arten, die die primären Produkten in einer Kettenverlängerungsreaktion unter anderem in höhere Carbonsäuren verwandeln (*Megasphaera sueciensis, Clostridium kluyveri*).

Neben der geeigneten Bakterienpopulation wird an der Optimierung der Konfiguration der Bioreaktor geforscht, welche den Mikroorganismen die idealen Vorrausetzungen für ihre Stoffwechselleistungen liefern sollen. Eine Besonderheit, die eine sehr hohe Novität besitzt, ist die Kombination der Syngasfermentation mit der sogenannten Elektrofermentation. Hierbei wird mit Hilfe einer kleinen angelegten Spannung der mikrobielle Stoffwechsel manipuliert und somit das erzeugte Produktspektrum in die gewünschte Richtung gelenkt. Wie entsprechende Versuche in Biofilmreaktoren zeigten, konnte vor allem die Bildung länger-kettiger Kohlenstoffverbindungen (C4-C8) erheblich gefördert werden.

In den Arbeiten besteht eine enge Kooperation mit dem K1 Kompetenzzentrum BEST - Bioenergy and Sustainable Technologies. Ziel ist das Up-scaling der derzeit noch im Labormaßstab durchgeführten Experimente in den Pilotmaßstab. Die neu errichtete 1 MW Dual-Fluid Vergaseranlage in Wien-Simmering bietet die ausgezeichnete Gelegenheit Versuche unter praxisnahen Bedingungen mit realem Syngas durchzuführen.

Use of the biopolymer chitosan as a flocculant for the treatment of digestate (FFG Project BioFlock)

DI Mag. (FH) Wolfgang Gabauer; University of Natural Resources and Life Sciences Vienna; BOKU Wien; Department of Agricultural Biotechnology, IFA-Tulln; Institute of Environmental Biotechnology; wolfgang.gabauer@boku.ac.at

Florian Kment B.Sc.; University of Natural Resources and Life Sciences Vienna; BOKU Wien; Department of Agricultural Biotechnology, IFA-Tulln; Institute of Environmental Biotechnology; florian.kment@boku.ac.at

DI Dr. Bernhard Stürmer; Kompost & Biogas Verband Österreich, Franz-Josefs-Kai 13; 1010 Wien; Stuermer@kompost-biogas.info

Themenbereich: Biomasse und reststoffbasierte Bioraffinerien

Flocculants are used in many areas of the water industry to remove pollutants and contaminants, such as colloidal particles, from wastewater. In some biogas plants flocculants are used in the treatment digestate in order to obtain a fraction with a higher dry matter content. The use of flocculants can increase the efficiency of further separation processes such as centrifugation or filtration. Reducing the volume of digestate can significantly reduce application costs. Common flocculants are polyacrylamide (PAM) or the coagulant iron chloride. Synthetic PAM, due to its synthesis, can have a very high molecular weight and is the basis for various flocculants. However, there are concerns about the release of PAM into the environment. There is also the risk of acrylamide residues during the synthesis of PAM. The biopolymer chitosan (CTS), which can be obtained from shrimp shells, crab shells or fungal mycelium is a possible alternative to conventional flocculants.

In the "BioFlock" research project the use of various CTS products as a flocculant on kaolin, digested sludge and digestate is investigated. In addition to conventional CTS, the CTS derivatives carboxymethyl CTS, N-succinyl CTS and quaternary CTS were used. The flocculation efficiency was determined by means of a jar test, particle measurements and the turbidity of the media. CTS was found to be suitable for flocculation of digested sludge followed by centrifugation, resulting in a reduction in particle number of 83%-99% compared to the blank.

The derivatives carboxymethyl-CTS and N-succinyl-CTS did not prove to be suitable flocculants. The jar tests with digestate showed that the amount of 0.04 kg CTS per kg dry matter was not sufficient to flocculate the particles in the digestate. The reduction in the number of particles after centrifugation with CTS was lower compared to the same amount of PAM and ferric chloride. At doubling the amount to 0.08 kg per kg dry matter, the separation of the particles in the digestate was improved. The best result with CTS was a particle reduction in the digestate of 79%. CTS could be a promising flocculant in the future due to its natural origin and biocompatibility, offering advantages over conventional products. In a degradability test (BOD-test), it was shown that chitosan (88 %) degraded better than PAM (20 %) over the same period of time.

Biowaste as resource for combined generation of materials and energy: concept and operation of a pilot-scale biorefinery with steam explosion and two-staged anaerobic digestion as core elements

Gregor Sailer
State Institute of Agricultural Engineering and Bioenergy, University of Hohenheim
Garbenstrasse 9, 70599 Stuttgart, Germany, gregor.sailer@uni-hohenheim.de, la-bioenergie.uni-hohenheim.de
Co-Authors: Marian Baumgart, Konstantin Dinkler, Dr. Benedikt Hülsemann, Dr. Hans Oechsner

The globally increasing energy demand and growing resource scarcity calls for an efficient utilization of biowaste or biogenic residues from agriculture, forestry, industry and municipalities. The organic fraction of municipal solid waste (OFMSW) represents a main fraction of the residential waste. As such it is one of the most complex and relevant biowastes. In Germany, it is prescribed per law to collect OFMSW separately (usually via biowaste bins) and approx. 5 million tons of OFMSW - which mainly contain a mixture of food, kitchen and garden waste - are currently collected each year[1]. This amount could be even higher due to the circumstance that a large share of the population still has no access to a biowaste bin or due to low collection levels of OFMSW in areas with available biowaste bin. Furthermore, recent studies have proven that large amounts of biowaste still remain in the residual waste bin. Additional challenges in the context of OFMSW are the share of impurities that complicate the processing at existing treatment plants and thus limit the re-application potential of generated products.

To date, OFMSW is utilized via composting and anaerobic digestion (AD) or in a combined treatment of the before-mentioned in order to produce biogas, digestate and compost products. In the AD of biowaste, dry digestion systems such as plug-flow (mainly thermophilic) or batch reactors (mainly mesophilic) represent common state-of-the-art technologies, especially when using OFMSW as sole or predominant feedstock. An evaluation of the German waste digestion market[2] has shown that those technologies differ especially regarding the achieved biogas yields (≥100 $m^3\ t_{OFMSW}^{-1}$ for plug-flow, ≤100 $m^3\ t_{OFMSW}^{-1}$ for batch reactors), which can be explained by the chosen process temperature and the technical efforts for OFMSW pre-treatment. This is drastically lower or even non-existent in the case of batch reactors. In wet digestion systems equipped with stirred-tank reactors, however, OFMSW is only used as co-substrate but usually those waste-digestion plants rely on different biowaste types with low dry matter (DM) concentration such as commercial food waste. Problematic is the current main objective of waste treatment plants as it primarily is the hygienic treatment and stabilization of biowaste. In addition, OFMSW contains biowaste types that are hardly degradable in AD such as fiber-rich, lignocellulosic components.

From a sustainability perspective, the inefficient utilization of biowaste has to be avoided. Therefore, alternative utilization methods that complement the conventional treatment approaches could improve the entire value chain of biowaste valorization while contributing to the transformation towards a bio-economy. Within the research project “Biowaste to Products (BW2Pro)” an innovative concept and the operation of a biorefinery in pilot scale with a treatment capacity of 1000 kg d^{-1} of OFMSW is evaluated. The concept consists of an OFMSW pre-treatment (sieving, shredding, sorting, hydro-cyclone) to remove impurities, a steam explosion technology to access the fibers, a solid-liquid separation with a fiber utilization plant and a two-staged AD, which in turn consists of a hydrolysis, a filtration unit and a methane reactor realized as a fixed bed for biogas production at preferably high organic loading rates. Based on this biorefinery approach, the objectives are to separate the fibers from the OFMSW mixture after steam explosion prior to the AD process to produce natural fibers for different material applications such as flowerpots (substitution of peat or plastic pots), agricultural fleeces or fiber composites. Simultaneously, the liquid and OFMSW-based by-product (“pulp” after solid-liquid separation) will be used as biogas substrate and its digestate as high-quality fertilizer.

Within preliminary studies, the material properties and energetic potential of the untreated OFMSW, which will be used as feedstock for the biorefinery, were determined. Both DM and organic dry matter (oDM) concentration vary depending on parameters such as settlement structure or season but they can be sufficiently specified. E.g., the range of values was 27.5 - 35.5%$_{\text{fresh matter (FM)}}$ for DM concentration with an average of 31.73 ± 2.40%$_{FM}$ and 70.6 - 90.4%$_{DM}$ for oDM concentration with an average of 83.35 ± 4.21%$_{DM}$ (both n=42)[1]. Together with results of the specific methane yield (SMY) of 297 ± 24 L kg_{oDM}^{-1} (determined via Hohenheim Biogas Yield Test according to VDI 4630), a FM-based SMY of approx. 80 L kg^{-1} was achieved. This SMY is considerable higher than those commonly achieved in full-scale AD plants as presented above.

In the planned biorefinery, however, only OFMSW-based liquids (after steam explosion) will be digested. For comparison and to evaluate the effect of steam explosion treatment, OFMSW press water was generated in a first step without prior steam explosion. Fresh OFMSW was separated into solid and liquid fractions with a tincture press at different operating pressures (10, 50 and 100 bar). All generated liquids were characterized with DM concentrations between 8-10%$_{FM}$, oDM concentrations between 68 - 75%$_{DM}$, pH-values of approx. 4.5 and SMY of 323 - 500 L kg_{oDM}^{-1}. The best OFMSW press water variant achieved a FM-based SMY of almost 40 L kg^{-1}. Thus, even without prior steam explosion a significant amount of energetic potential can be transferred to the liquid phase by sole pressing. However, the fibers cannot be separated from the remaining solid fraction and would thus remain unused without prior steam explosion.

[1] Sailer et al. 2021, Characterization of the separately collected OFMSW from rural and urban districts for a one-year period in Germany. Waste Management. doi: 10.1016/j.wasman.2021.07.004.
[2] Own evaluation based on data of Kern and Raussen 2021 (Biogas Compendium 2021/22).

Effiziente Synthese von Methanol aus reformiertem Biogas

Biomasse- und Reststoffbasierte Bioraffinerien/Bio CCU und CCS

Carl Fritsch, fritsch@fiw.rwth-aachen.de, +49 241 80 2 39 55

Jule Blankenstein, blankenstein@fiw.rwth-aachen.de, +49 241 80 2 68 49

Methanol ist eine der meistgehandelten Flüssigchemikalien der Welt. Rund 110 Mio. t. werden weltweit jährlich produziert und gehandelt [1]. Bisher werden ca. 99% der Chemikalie auf Grundlage fossiler Ausgangsstoffe, überwiegend Erdgas und Kohle, hergestellt.

Eine Möglichkeit Methanol vollständig erneuerbar herzustellen ist die Synthese der C1-Plattformchemikalie durch Reformierung von Biogas zu Synthesegas und die katalytische Herstellung von Methanol daraus.

Während die Synthese von Methanol aus CO-reichem Synthesegas aus der Reformierung von Erdgas ein großtechnisch vielfach umgesetztes und stark optimiertes Verfahren ist, birgt die äquivalente Herstellung aus CO_2-reichem Biogas folgende technische Hürden:

- Die Reformierung von Biogas (ca. 60% CH_4/40% CO_2) erfordert durch den – im Vergleich zu Erdgas – erheblich geringeren Heizwert einen deutlich höheren Einsatz des Biogasfeeds zur Erreichung der notwendigen Verfahrenstemperaturen.
- Der hohe Anteil an CO_2 im Biogas bedingt für die Einstellung eines stöchiometrischen Verhältnisses von CO/CO_2 zu H_2 im Synthesegas die Zugabe von zusätzlichem Wasserstoff
- Die kommerziell eingesetzten Katalysatoren für Herstellung von Methanol durch die Hydrierung von CO sind auf die Selektivität für CO optimiert. Die effiziente Hydrierung von CO_2 erfordert Fortschritte in der Katalysatortechnik, um die gegenüber der Erdgas-basierten Synthese veränderten Synthesegaszusammensetzungen effektiv umsetzen zu können

In einem durch das Bundesministerium für Wirtschaft und Klimaschutz (BMWK) geförderten Projekt adressiert das Forschungsinstitut für Wasserwirtschaft und Klimazukunft an der RWTH Aachen (FiW) e.V. alle oben genannten Punkte. Die Ergebnisse werden an einer Pilotanlage demonstriert.

Die ersten Ergebnisse der Versuchsphase an der Pilotanlage, an der ein integriertes System aus autothermem Reformer, Methanolsynthese, Produktabscheidung, Gasrecycling und Purge geprüft wird, zeigen, dass der Verfahrensansatz Potenzial zur kommerziellen großtechnischen Umsetzung an Bio- und Klärgasanlagen hat.

Neben der Reformierung des gesamten Biosgases ist auch eine Abscheidung des CO_2 mit subsequenter Synthesegaserzeugung durch Zugabe von Elektrolysewasserstoff als nachhaltiger Verfahrensansatz denkbar. Im Vergleich zum pilotierten Verfahren sind alle hierfür benötigten Verfahrenskomponenten (bis auf den Katalysator für die Synthese) in industriellem Maßstab verfügbar.

In der Präsentation werden zunächst die ersten Ergebnisse der Pilotversuche gezeigt. Weiterhin werden beide Ansätze – die Reformierung des Biogases sowie die Abscheidung des CO_2 und Aufbereitung zu Synthesegas – aufbauend auf der Pilotierung des Verfahrens gesamtenergetisch und wirtschaftlich gegenübergestellt. So wird das marktseitige Potenzial der Methanolsynthese aus reformiertem Biogas hergeleitet.

[1] MMSA Global Supply and Demand 2022; Methanol market Services Asia; Singapur 2022

Innovative solutions for resource- and cost-efficient production of biomethane in agriculture

Kirsikka Kiviranta,
VTT Technical Research Centre of Finland
P.O. Box 1000, FI-02044 VTT, Finland
kirsikka.kiviranta@vtt.fi

Co-Authors: Heidi Saastamoinen, Elina Mäki, Saija Rasi, Janusz Gołaszewski, Christina Zinke

Agricultural regions have potential to valorise low-quality feedstock to biogas and other products. However, there remains challenges especially related to cost-efficiency, which are important to be tackled, in particular given the current energy crisis in Europe calling for much higher domestic production of energy. Issues related to resource- and cost-efficiency are addressed in public funded research projects BRANCHES and HABA. BRANCHES (Boosting rural bioeconomy networks following multi-actor approaches) is a HORIZON2020 project, in which currently available and feasible biogas production practises, among other bioeconomy solutions, already implemented in agriculture and rural regions have been screened by local project partners in Finland, Spain, Italy, Poland and Germany. The practise-oriented knowledge of the most innovative and cost-efficient practises have been summarized and shared to farmers and practitioners in these countries. In addition to the knowledge transfer of the most promising solutions, BRANCHES project aims to understand the factors affecting the success of the identified biogas production practises by collecting drivers and barriers related to their replicability potential in other regions and markets.

The findings show that there is a large variation especially in the scale and business model applied in the most promising and feasible biogas solutions in agriculture. Biogas can be produced from side and waste streams (e.g., manure, post-distillery brew, fruit and vegetable residues, overdue food) of a single farm but in some cases several farms have come together to produce biogas in a centralized plant. The centralized collection of cattle slurry and manure can be especially beneficial to agricultural producers that do not have enough agricultural area to spread the manure to. In some examples, the local municipality is supporting biogas production by e.g., being a participant in a biogas production cooperative or by buying the energy or produced transportation fuel.

The product biogas can be used to cover the farm's own heat and electricity demand and the digestate to contribute to farm's fertilizer demand. The produced gas can be also sold outside the farm in the form of energy or upgraded to biomethane, which is applicable as a transportation fuel for instance in the milk collection trucks or in passenger cars. The digestate can also be used in organic fertilizer production to form another income source. Recently, biomethane production through hydrogen biomethanation has taken steps towards commercialization. A key precondition for the profitability of biogas production seems to be, that the demand meets the supply.

Although existing examples of successful biogas production practises can already be found, the investment costs for the biogas production and upgrading are generally considered high. Thus, improving cost- and resource-efficiency of biogas production would benefit the farmers, but new technological solutions are still required for that. In HABA project (Decentralized and resource-efficient production of biomethane in Central Finland), funded by the REACT-EU instrument to support regions affected by COVID-19, several technologies are being piloted with the aim to increase biogas production potential by biogas upgrading and exploiting the produced side-products.

The technologies piloted in the project include a) biological in-situ methanation by injecting hydrogen into biogas digestor in lab- and pilot scale, b) using membrane contactor in separating carbon dioxide from biogas into an absorbent solution, c) purifying, compressing/liquefying, and bottling carbon dioxide separated from biogas to create product quality CO_2, and d) improving the utilization possibilities of the digestate by improving the separation process. One target of HABA project is to increase profitability of decentralized biogas production. For instance, the more cost-effective upgrading of biogas into a transport fuel (biomethane) can make a previously unprofitable project plans profitable. In addition, creating value for carbon dioxide, currently released to the atmosphere, can have positive impacts on the investment decisions through economics and climate impacts.

09:00–12:30 Uhr

Highlights der Bioenergieforschung 2023 (Teil 1)

Nationale & internationale Ergebnisse aus den IEA Bioenergy Tasks

09:00 am–12:30 pm

Highlights of Bioenergy Research (Part I)

National & international results from the IEA Bioenergy Tasks

IEA Bioenergy Task40 - Deployment of biobased value chains for a Circular Bioeconomy

Fabian Schipfer[x], Bettina Muster[#], Judith Buchmaier[#] & Michael Wild[*]

[x]Technische Universität Wien, Institut für Verfahrenstechnik, Umwelttechnik und Technische Biowissenschaften; www.schipfer.eu, fabian.schipfer@tuwien.ac.at

[#]AEE INTEC- Institut für Nachhaltige Technologien; j.buchmaier@aee.at, b.muster@aee.at

[*]Wild und Partner KG; michael@wild.or.at

The focus of Task 40 in the triennium 2022-2024 is on the development and design of efficient, economically viable, and bankable value chains to support a more significant deployment of sustainable biomass for energy, but also biobased products, chemicals, and materials, considering food, feed and fiber markets. In short, Task40 aims at deploying sustainable biomass for energy in the context of the larger Circular Bioeconomy.

The work within the Task40 and together with other Tasks and IEA Technology Collaboration Programs (TCPs) evolves around three work packages:

WP1 on Market Developments includes a continuation of the regional transitions project in which we devised strategies to increase the mobilization and deployment of local (endemic) low-value heterogenous solid biomass resources. A collaborative Intertask project on market perspectives and deployment of aviation and marine biofuels was also initiated.

WP2 on Industrial Heat and Processes builds upon the publications of the last triennium on technologies, markets, and processes for high-temperature bioheat for industrial applications. This triennium, the strategic Intertask project, consolidates the knowledge and research of all IEA Bioenergy Tasks and the collaborative Intertask project on industries suitable for Bioenergy Carbon Capturing, Utilization, and Sequestration (BECCUS).

WP3 is dedicated to deployment strategies. The strategic Intertask project on the role of bioenergy in a Well-Below-2°C / Sustainable Development Goals (SDG) world is now complemented by the Intertask work on the deployment and markets of renewable gases (including green hydrogen, biogas, and biomethane). A new project on deployment guidance regarding technological barriers, economic aspects, financing, and a collection of success stories is planned.

The Austrian delegation to Task40 participates in each Work Package. Additionally, we aim to consolidate the interdisciplinary approaches applied in the various thematic areas based on fundamental research and discussions. Therefore, we are shifting our focus from value chains to value networks. This perspective allows us to investigate network dynamics emerging from system integration between food, material, and energy use of biomass, and with complementing transformation strategies based on renewable electricity, hydrogen, and Circular Economy concepts. This meta-study tries to answer the following questions:

1. What are the benefits of system integration, aka multi-sector coupling?
2. How can we measure and account for the possible multiple benefits of system integration?
3. And how can we design market and decision-making frameworks to reward those benefits?

The meta-study will accompany the various thematic areas, find application in selected case studies, and be discussed based on a more abstract and generalized level during the current triennium. We encourage collaboration requests, especially on the outlined research questions within and beyond the IEA Bioenergy TCPs.

13:30–15:00 Uhr

Parallelblock 3

Bioenergie – ein notwendiger Teil der Transformation unseres Energiesystems – Potenziale & Notwendigkeiten

01:30 pm–03:00 pm

Parallel session 3

Bioenergy – an essential part of the transition of our energy system – potentials & needs

The Possible Role of Biofuels in A Climate Neutral Transportation Sector in Austria

Gerfried Jungmeier
JOANNEUM RESEARCH
Waagner-Biro-Str. 100, 8020 Graz, Austria
gerfried.jungmeier@joanneum.at
Michael Schwingshackl
Graz University of Technology, Graz, Austria
schwingshackl@ivt.tugraz.at

The environmental effect of vehicles can only be assessed based on life cycle assessment (LCA) covering production, operation and end of life. The methodology of dynamic LCA is used for future scenarios of the Austrian vehicle fleets – covering passenger vehicles, trucks, buses, 2-wheelers, trains and ships - for reaching climate neutrality in 2050 and to identify its necessary framework conditions. Based on the historic development and the current vehicle stock scenarios are developed to reach the following goals: 1) 2030: 48% GHG reduction compared to 2005; 2) 2040: climate neutrality for the Austrian transport sector and 3) 2050: climate neutrality for all global GHG emissions in dynamic LCA. The main energy carriers for climate neutrality are 1st and 2nd generation biofuels, renewable electricity and hydrogen as well as e-fuels to be used in (battery or overhead line) electric systems, internal combustion engines and fuel cells vehicles. The analysed scenario differ in the development of the vehicle stock and the different shares of (bio)fuels, hydrogen and electricity.

The results show that a strong electrification of the passenger vehicle fleets and the use of hydrogen and biofuels for trucks and busses, where electrification is due to required range, refuelling time an weight is not possible, will lead to a climate neutral transport sector in Austria using mainly domestic sustainable energy sources – forest biomass, hydro and wind. The possible role of e-fuels is very limited due to its low energy efficiencies. The biggest challenge is to reach a 48% GHG reduction already by 2030. The main influences to reach climate goals in Austrian vehicle fleet are: 1) increasing number of newly registered electric vehicles in all segments 2) development of total vehicle stock, 3) development of annual driven mileage of vehicle fleet, 3) generation of additional renewable electricity, 4) more efficient use of biomass and 5) rapid increase of wood-based biofuel production. The conclusions on the future role of biofuels in climate neutral society in Austria are the efficient use of biomass in biorefineries for broad product portfolio with its main products food & feed, carbon-based materials &chemicals and carbon-based fuels for heavy vehicles.

The role of biofuels in the transition toward sustainable transport system

Amela Ajanovic
Energy Economics Group
Vienna University of Technology (TU WIEN)
Gusshausstr. 25-27/370-3, 1040 Vienna, Austria
e-mail: ajanovic@eeg.tuwien.ac.at,
web: http://eeg.tuwien.ac.at

Currently the transport sector accounts for a quarter of total greenhouse gas emissions in the EU. According to the European Green Deal, it will be necessary to make significant changes in the transport sector to be able to reach climate neutrality by 2050. Although, currently major focus is put on the electrification of mobility, there are still significant challenges related to the broader use of battery electric vehicles. At least in the next decade biofuels should play an important role in the realisation of the European decarbonisation targets.

However, over the last decade, with the increasing use of biofuels some challenges, such as sustainability of biofuels or competitions with food production have become more evident. Therefore, the policy framework was changeable over time leading to the lower of investments in biofuels worldwide, especially in the first-generation biofuels.

The major goal of this work is to analyse and discuss the development of the biofuels use over the last years as well as to investigate impact of the COVID-crisis and Ukraine-war on the policy framework. Of special interest is to identify major differences between countries and to identify positive examples and derive lessons learned.

The future prospects of biofuels are very dependent on three issues: (i) the development of their economic and (ii) environmental performances, especially CO2 emissions, as well as (iii) policy support, e.g. subsidies and quotes. Due to the current crisis, of special interest is the potential competition between fuel and food production. Many countries have already prepared proposals for the reduction of the blending mandates. A major conclusion is that the time of political promotion of biofuels is widely over, especially due to the current crisis and announced ban on internal combustion engine vehicles and there are no bright prospects for biofuels are on the horizon.

ON THE ECONOMICS AND POTENTIALS OF BIOMASS-BASED GREEN GASES IN AUSTRIA

Reinhard Haas, Amela Ajanovic, Frank Radosits, Marlene Sayer

Energy Economics Group, Vienna University of Technology,

Gusshausstrasse 25/370-3, A-1040 Vienna,

E-mail: Haas@eeg.tuwien.ac.at

Green gases based on biomass are considered as an important mean to cope with environmental and supply security problems in natural gas supply. The core objective of this paper is to investigate the perspectives of biomass-based green gases from economic and ecological points-of-view in a dynamic framework till 2050 for Austria. In addition the potentials in such a dynamic framework will be analyzed.

The fuels investigated are:

- biogas respectively biomethane from organic waste, maize silage or grass;
- Synthetic natural gas (SNG) from different wood sources, straw and forest wood residues;
- hydrogen from biomass.

The major results is, that actually there is a considerable potential for green gases from biomass. The major barrier are the still high production costs mainly because of the high investment costs of the conversion plants / biorefineries. This leads to an unfavourable economic performance in comparison to fossile natural gas at price levels of 2000-2020.

Yet, if a proper CO2 tax is implemented and prices of fossil fuels will remain high and given that other current policies discussed are put in practice, green gases could become economically competitive already in the next years,

The major conclusion is that biomass-based green gases will play a significant role only if the proper mix of CO2-taxes, intensified R&D, investment subsidies and corresponding riding down the Learning Curve of the investment costs of the conversion plants/ biorefineries are timely implemented. Or if especially the natural gas prices remain at price levels significantly higher than over the period 2000-2020

The Strategic Role of Bioenergy

Dina Bacovsky
BEST – Bioenergy and Sustainable Technologies
Gewerbepark Haag 3, 3250 Wieselburg-Land, Austria
dina.bacovsky@best-research.eu,
www.best-research.eu

Co-authors: Elisa Carlon, Christa Dissauer, Bernhard Drosg, Matthias Kuba, Doris Matschegg, Christoph Schmidl (all with BEST – Bioenergy and Sustainable Technologies), Florian Kraxner (IIASA), Fabian Schipfer (TU Wien), Vera Djemelinskaia

Bioenergy, an important element in combating climate change, securing energy supply, and providing income through regional biomass-supply chains, is today the largest source of renewable energy globally. Biomass can be used to produce power, heat, cooling, transport biofuels, and intermediate bioenergy carriers, such as renewable gas. Bioenergy can substitute fossil energy carriers and thus reduce energy-related greenhouse gas (GHG) emissions. Sustainability, however, is key.

GHG emissions, the emission of local air pollutants, biodiversity, land and water use, etc., are all important elements of **environmental sustainability**. Sustainably managing forests and agricultural landscapes can deliver biomass for bioenergy to reduce GHG emissions while also maintaining or improving biodiversity, carbon sinks, and species abundance. In many regions, bioenergy has to comply with strict sustainability criteria and standards so as to assure effective GHG emission reductions; moreover, there is a growing awareness that preserving stocks of carbon in the soil, as well as biodiversity conservation, should be important elements in all our activities.

As for **economic sustainability**, being price-competitive with other (fossil or renewable) energy carriers is one of the biggest challenges for bioenergy. Significant quantities of biomass can be supplied at low cost, for example, straw from food/feed crop production, residues from wood or food processing industries, used cooking oil or other biogenic wastes; but when larger quantities are needed, also higher-cost biomass has to be used. Costs for biomass feedstocks and bioenergy carriers vary regionally and also depend on their intended use and competition from other market actors for the same feedstocks.

It is essential to invest in **mobilisation of biomass** but this needs to be carefully managed to safeguard the environment; biomass—being a limited resource—should be used wisely and efficiently. Wherever basic energy needs are met, a cascading use of biomass feedstocks is becoming a requirement.

Social sustainability, finally, deals with how sustainability affects people, their health and well-being, and their ability to make a decent living. The 17 Sustainable Development Goals (SDGs), which all United Nations Member States have adopted and aim to achieve by 2030, balance the three dimensions of sustainability—environmental, economic, and social—and aim for a just transition to a sustainable future. Today, about 2.8 billion people globally still lack access to clean cooking solutions, relying on traditional burning of biomass over open fires to heat their food. Modern bioenergy, namely the use of commercial solid, liquid or gaseous biomass-based fuels in efficient appliances, can play an important role in achieving the SDGs, directly contributing, for example, to better health and well-being, affordable and clean energy based on local resources, and action against climate change.

Biomass can be used in many different ways, using a **wide range of technologies**. Biorefineries split biomass into disparate fractions that can be processed into a variety of products, including materials, chemicals, animal feed, pharmaceuticals, and energy, thus contributing to the bioeconomy. Intermediate bioenergy carriers, such as torrefied pellets and pyrolysis oils and other biocrudes, can be used to store energy, making transportation of the energy carrier more efficient. Bioenergy installations can provide heat and electricity on demand, cover baseload and peak demands, or shift energy provision between seasons. Solid, liquid, and gaseous bioenergy can be used in sectors that are otherwise hard to decarbonise, such as high-temperature heat production for industry or long-distance aviation, heavy-duty transport, and international shipping. Moreover, combining bioenergy with carbon capture and storage (CCS) can achieve **net negative GHG emissions**.

Despite its many benefits, the growth of sustainable bioenergy is still below the level needed for the desired energy transition. **Governance systems** are needed to assure sustainable sourcing of biomass feedstocks, their efficient conversion to renewable energy, and their deployment. Biomass trade needs to connect biomass supply and end markets. Policymakers have a crucial role to play in facilitating the energy transition, by giving it priority, creating markets for sustainable, low-carbon technologies, and promoting research and development.

Facilitating biomethane production via cross-border ownership transfer of certificates

Julian Auderieth
AGCS Gas Clearing and Settlement AG
Alserbachpalais - Alserbachstraße 14-16, 1090 Vienna
info@biomethanregister.at
www.biomethanregister.at

Co-Authors: Stefanie Königsberger, Andreas Wolf, Franz Keuschnig, Sarah Piza, Stefan Thaller

According to the REPowerEU initiative, as published by the European Commission in 2022, the annual production goal for biomethane is set to 35 bcm[1] by 2030[2], an almost tenfold increase of the current production of 3.6 bcm per year[3]. An ambitious goal, given the fact that subsidy schemes for biomethane vary widely within the EU Member States, which often renders biomethane production unfeasible from an economic perspective unless gas prices stay at least above 55€/MWh[4]. Details on how to reach the goal are included in the Biomethane Action Plan, a dedicated point in the REPowerEU initiative, targeting this topic[5]. Aside from technical challenges and necessary adaptions in legislation, cross-border ownership transfer of biomethane in Europe may accelerate the rise in production and interest in biomethane consumption by making the renewable gas product available to a higher number of market participants throughout Europe. Using certificates and national registries for the documentation and tracking of the intrinsic, renewable value of renewable gases provides the necessary market tools to enable mass-balancing of biomethane along the interconnected European gas grid. This prevents double counting and sets a universal standard to harmonize the biomethane market across Europe.
The EU-funded H2020 project REGATRACE supports the development of national biomethane markets in dedicated Target and Supported countries by removing non-technical barriers for cross-border transactions of European Biomethane certificates. The "REGATRACE Network" was developed as an overarching solution to several bilateral or multilateral agreements, bringing all organisations responsible for the documentation of renewable gas on one table, which is yet unique in Europe. The project results show that a bottom-up approach is necessary to sustainably integrate renewable gases into the European energy market: 1st step: Establishing national registries - 2nd step: Harmonize the certification process (GoO[6], PoS[7], auditing criteria, Mass balancing etc.) - 3rd step: Connect national registries via a common European scheme (ERGaR[8]) - 4th step: Enable cross border ownership transfers – 5th step: provide security via a harmonized framework throughout Europe with clear production guidelines and definition of desired application purposes of renewable gases to facilitate market growth. Outlook: Given the ambitious goal of 35 bcm until 2030 and the uncertain supply situation of gaseous energy carries in the year 2022, several measures leading towards renewable energy production within the EU should be taken. While, based on the exchange with various stakeholders, a common European scheme for ownership transfer will not lead to a tenfold increase in production quantities on its own, it is expected to facilitate the process significantly.

[1] Billion cubic meters
[2] REPowerEU (europa.eu)
[3] 6th European Biomethane Benchmark (sia-partners.com)
[4] A way out of the EU gas price crisis with biomethane | European Biogas Association
[5] EUR-Lex - 52022SC0230 - EN - EUR-Lex (europa.eu)
[6] Guarantees of Origin
[7] Proof of Sustainability
[8] European Renewable Gas Registry

13:30–15:00 Uhr

Parallelblock 4

Treibstoffe aus Bioraffinerien

01:30 pm–03:00 pm

Parallel Session 4

BtL Biorefining Processes

Residual forest biomass for combined production of food and biofuel

Shaojun Xiong[1], Carlos Martín[2], Feng Chen[1,3]*

[1] Swedish University of Agricultural Sciences, Department of Forest Biomaterial and Technology, SE901 83 Umeå,
Sweden; [2] Inland Norway University of Applied Sciences, Department of Biotechnology, N-2317 Hamar, Norway; [3] Anhui Agricultural University, School of Horticulture, Hefei 230036, China.

*Presenter * Contact Details: Email: Shaojun.Xiong@slu.se, Tel +46-907868778*

Growth of global population and climate change as well as potential breaks in the supply chains due to global-scale crisis such as the covid-19 pandemic underline the importance to develop sustainable solutions to increase regional food and fuel security as well as resource and energy efficiency. We have in recent years developed an approach of using local wood resources for integrated production of edible mushroom and biofuel, which is proved to be a promising strategy for the countries such as Sweden where > 60% of the food is imported but forest residues are plentiful.

The approach is based on a sustainable production of high value non-meat protein by cultivation of white-rot edible mushroom such as shiitake (Lentinula edodes) on low-value wood residues. During the cultivation, the wood is broken-down and delignified by the mushroom thus enabling an efficient bioconversion of cellulose contained in the wood into fuel ethanol. Then solid-leftovers after enzymatic saccharification can be also used as fuels for heating.

Our major research work was to investigate: 1) the factors that affect both mushroom production and substrate lignocellulosic degradation during the cultivation; 2) the consequences for enzymatic saccharification of spent mushroom substrates and for fermentation of cellulose hydrolysates to ethanol. Shiitake growing on designed hardwood substrates was used as a study model. One of the most significant findings is that the substrate composition with around 0.6% nitrogen and 10% bark fraction could minimise cellulose loss from conventional >50% to 20% but maximise lignin degradation to >70% of that in the initial mass, leading to optimal production of both mushrooms and bioethanol. It was understood that the delignification by fungus was correlated with degradation of syringyl lignin unit, but not related to substrate crystallinity. Also, phenolics were found to be considerably formed from lignin degradation and acidic acid was mostly formed during enzymatic saccharification, but both byproducts were too low to inhibit processes of saccharification and fermentation, which shows a remarkable advantage over conventional thermochemical pretreatment of lignocellulose for producing ethanol. The shiitake cultivation, as biological pretreatment for facilitating the lignocellulose bioconversion, results in also increased nitrogen solubility thus providing easily-accessible nitrogen sources for supporting ethanolic fermentation.

It is estimated that 1000 kg dry mass of birch-based substrates can produce up to 600 kg fresh shiitake mushrooms (90% water), ~130 litre fuel-ethanol and ~300 kg solid leftovers for heat generation, based on our experimental data.

Demonstration of the coupling of the novel aqueous phase reforming process with the Fischer-Tropsch process at lab scale

Stefan Arlt
BEST – Bioenergy and Sustainable Technologies GmbH
Mariahilfer Straße 51/1/15a, 1060 Vienna, Austria
stefan.arlt@best-research.eu
www.best-research.eu

Co-Authors: Gerald Weber, Stephan Hochgerner, Matthias Grüner, Reinhard Rauch, Hermann Hofbauer

To ensure the economic and environmental sustainability of biorefineries it is crucial to utilize the feedstocks to the fullest extent possible. One key strategy to achieve this goal is to valorize secondary streams and integrate different processes to utilize synergies between them.
Aqueous phase reforming (APR) is a comparatively new process in which a hydrogen-rich gas is produced by catalytically reforming organic compounds dissolved in an aqueous solution at relatively low temperature and high pressure. It therefore enables the valorization of carbon-laden residual waters, which commonly occur as a by-product in biorefinery processes. The Fischer-Tropsch (FT) synthesis, which is known for almost a century, can be used to produce synthetic fuels from syngas. Syngas obtained from dual fluidized bed steam gasification of woody biomass usually exhibits a H_2/CO ratio below 2. For FT synthesis however, the ideal ratio would by just above 2.
By coupling the two processes, as envisaged by the Heat-to-Fuel concept, the hydrogen from APR can be used to increase the H_2/CO ratio of the syngas that is used in the FT synthesis. This work demonstrates this concept by coupling the APR with the FT process at lab scale.

For the demonstration two independent plants were built. Since to our knowledge APR has only been studied on a bench scale so far, the process demonstration unit built for this endeavor is the largest continuous plant on this scale to date. The plant was designed to process up to 44 l/h of carbon-laden residual waters. However, the experiments were conducted using a synthetic aqueous phase containing 1 wt% organics. The fixed bed reactor used a platinum-based catalyst and was operated at 260 °C and 55 barg.
The FT unit was rebuilt from a previously existing unit and retrofitted with a millistructured FT reactor. For syngas, around 1.25 Nm^3/h of a 2:1:2 mixture of hydrogen, carbon monoxide and nitrogen from gas cylinder bundles was used. The millistructured reactor used an innovative cobalt-based catalyst and was operated at a temperature of 230 °C and a pressure of 20 barg.

After operating the two plants independently for several hundred hours, both units were coupled and the APR gas was fed to the FT unit. Since the APR product gas consisted of approximately 70 vol% hydrogen and 30 vol% inerts the composition of the syngas was adjusted to maintain the 2:1:2 ratio previously used. The coupled operation was demonstrated in one continuous experimental run for 50 h. During this run, close to 190 Nl/h of syngas was substituted with APR product gas, which is about 15 %. Under these conditions a carbon monoxide conversion (per pass) of around 30 % and a methane selectivity of around 20 % were achieved. Both the reactor performance and the product composition were comparable to that obtained during previous stand-alone FT experiments under the same conditions.

The demonstration shows that the coupling of the APR and FT processes is feasible on a technical level. Combining the two processes allows to use carbon-laden residual water that otherwise would be treated as waste water for the production of green hydrogen, which in turn is used to produce sustainable biofuels. The integration does not lead to any significant drawbacks with regards to process performance or product quality.

Acknowledgment: The work was performed within the H2020 project Heat-to-Fuel. This project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No. 764675 and the COMET program under grant agreement No. 869341. The COMET program is managed by the FFG and is co-financed by the Republic of Austria and the Federal Provinces of Vienna, Lower Austria, and Styria.

TO-SYN-FUEL: Sustainable fuels made from biomass residues – demonstration on long-term operating plant

Stefan Eder, M.Sc.
Fraunhofer UMSICHT
An der Maxhütte 1, 92237 Sulzbach-Rosenberg
stefan.eder@umsicht.fraunhofer.de
www.umsicht-suro.fraunhofer.de

Co-Authors: Prof. Dr. rer. nat. Andreas Hornung[1)], Dr.-Ing. Robert Daschner[1)], Dr. Andreas Apfelbacher[1)]
[1)]Fraunhofer UMSICHT, An der Maxhütte 1, 92237 Sulzbach-Rosenberg

The H2020 To-Syn-Fuel project demonstrates a sustainable process able to transform waste biomass such as sewage sludge with nominal capacity of 500 kg/h into renewable liquid fuels and hydrogen. The Thermo-Catalytic Reforming® (TCR®) is implemented in a new process integrated with hydrodeoxygenation (HDO) and pressure swing adsorption (PSA) technologies to convert a wide range of residual biomass into three main products. H_2-rich synthesis gas (approx. 100 Nm³/h), biochar (approx. 250 kg/h), and a liquid bio-oil (approx. 50 L/h) that will be upgraded to green fuels (approx. 35 L/h) such as green TCR®-Diesel capable of being used directly in automotive internal combustion engines without modification, as they fulfil the EN 590 fuel standard.
Within this presentation, the results of the operational phase of the demonstration unit are shown. Until spring 2022, the plant was in operation for more than 1000 h and more than 40.000 L of crude oil have been produced so far. The main purpose of this unit is the long-term operation of a pre-commercial demonstrator. This is the final step of development before the technology reaches full commercial scale.

THE PLANT AND THE PROCESS

The liquid bio-oil from the ToSynFuel plant is refined to drop-in transport fuels using the hydrogen from the produced TCR® gas fraction. However, this hydrogen needs to be purified first. Hydrogen is separated from other species, like CO, CO_2 and CH_4 using the technology of project partner HyGear: Pressure Swing Adsorption (PSA). The separation is based on variation of adsorption capacity of an adsorbent as a function of operating pressure. The cleaned hydrogen is compressed and redirected to the hydrodeoxygenation reactors or can be used for other applications, like fuel cells. The required purity of the hydrogen can be controlled by the PSA settings. The existing PSA technology has been modified to meet the specification of the TCR® gas combined with recycled hydrogen out of the HDO part of the To-Syn-Fuel plant. To-Syn-Fuel is designed to set the benchmark for future sustainable development within Europe, by providing a valuable example of sustainable synthetic fuels and green hydrogen production to the rest of the world, while successfully addressing energy, environmental, economic and social needs. By the end of the project the TCR®/PSA/HDO technology will have been validated at TRL-7 (system prototype demonstration in operational environment) and the business plan and environmental/social sustainability analysis for the technology will be complete. The location of the demonstrator is in Bavaria, district of Amberg-Sulzbach near Fraunhofer UMSICHT institute, in the south of Germany. The demonstration facility has been accommodated to include site buildings and utilities.

CRUDE TCR®-OIL

The TCR®-demonstration-scale reactor is in operation. The plant includes a continuous operating reactor with a throughput of approx. 500 kg per hour and has a feeding unit with a sluice system to ensure an oxygen free atmosphere in the TCR®-system. The TCR®-500 demonstrator is a thermal heated two-stage reactor system with a downstream product gas treatment including a condenser stage. After removing the liquid product from the condensation unit, a separation of water and bio-oil takes place as the bio-oil is nonpolar. The bio-oil accumulates above the process water with a clear phase boundary (**Fehler! Verweisquelle konnte nicht gefunden werden.**) allowing the bio-oil to be extracted.

TCR®-oil generated from different feedstocks is comparable regarding the overall quality, no matter what feedstock is used. Outstanding properties are low water, ash, and oxygen content, along with a high carbon content, resulting in a high heating value (around 34.0 MJ kg^{-1}). Furthermore, the properties of the TCR®-oil are stable at long-term storage and due to its thermal stability atmospheric distillation is possible.

HYDROGENATION

To reach a unique bio-fuel quality meeting European standards like EN 228 and EN 590 for common gasoline and diesel, the removal of heteroatoms like sulphur, nitrogen, and oxygen is necessary. The crude TCR®-oil is hydrogenated in multi-stage reactors. The integrated HDO plant is designed for processing up to 35 kg/h TCR®-oil, which produces about 20 l/h refined diesel and 3 l/h raw-naphtha. Further investigations show that the biofuels produced by the hydrogenation of TCR®-oil comply with the European standards like EN228 and EN590 for common gasoline and diesel. The analysis spectra of the GCxGC/MS analysis of fossil diesel and TCR®-diesel look nearly the same.

To-Syn-Fuel project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement N° 745749.

Sustainable aviation fuel from hydrothermal liquefaction of sugarcane bagasse and straw: techno-economic and environmental assessments

Author: Raquel de Souza Deuber

School of Food Engineering, University of Campinas

São Paulo, Brazil

r211589@dac.unicamp.br

Co-authors: Jessica Marcon Bressanin, Antonio Bonomi, Leonardo Vasconcelos Fregolente, Marcos Djun Barbosa Watanabe.

Research and development on biofuels for long-haul applications are crucial for the reduction of greenhouse gas emissions in the transportation sector. The Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA) has set a goal of carbon neutral growth from 2020 for the international civil aviation, that will require an offset of about 2.5 billion tonnes of CO_2 between 2021 and 2035. Hydrothermal liquefaction (HTL) is a thermochemical process that converts a wide range of wet biomasses into bio-crude oil, which can be upgraded into sustainable aviation fuel (SAF). The sugarcane industry in Brazil generates a significant amount of bagasse and straw which could be partially used to produce HTL SAF, thus representing an opportunity to increase the participation of renewable fuels in the Brazilian energy matrix and to mitigate impacts from climate change.

This study presents an integrated assessment which evaluates the technical, environmental, and economic performances of the conversion of sugarcane bagasse and straw through HTL into advanced biofuels. Moreover, the integration of the HTL technology to the current sugarcane industry was also investigated, using a methodology based on process modelling and simulation of both agricultural and industrial stages involving biofuel production.

The results indicate that integration of the HTL with a sugarcane ethanol distillery has significantly increased the internal rate of return compared with the stand-alone HTL configuration, and that the selection of the liquefaction solvent is a very sensitive parameter to the economic feasibility of HTL. In this case, organic solvents such as ethanol may not be feasible at industrial scale, while water has showed much higher economic potential.

The minimum selling price of the HTL sustainable aviation fuels reached parity with fossil jet fuel at the best integrated scenario, showing a very high market-competitiveness. On the other hand, stand-alone HTL plant did not demonstrate economic feasibility. This indicates that the integration of first- and second-generation technologies may be crucial to this conversion pathway, since thermochemical conversion benefits from a technological maturity of current sugarcane industry, thus leveraging the second-generation plant by diluting costs and providing a low-cost feedstock.

Despite of that, the assessed scenarios have showed environmental sustainability. The life cycle emissions (cradle-to-grave) of HTL aviation fuel reached a substantive reduction when compared to fossil jet fuel, up to 82%.

13:30–15:00 Uhr

Parallelblock 5

Bioenergie in der Praxis

01:30 pm–03:00 pm

Parallel Session 5

Bioenergy in practice

QM Heizwerke supports the sustainable heat transition

Sabrina Metz
AEE - Institute for Sustainable Technologies
Feldgasse 19, 8200 Gleisdorf, Austria
s.metz@aee.at
https://www.aee-intec.at
Co-Authors: Christian Ramerstorfer, Stefan Retschitzegger, Ingo Leusbrock

For more than 15 years, the quality management programme klima**aktiv** QM Heizwerke has accompanied funded biomass district heating systems in Austria. QM Heizwerke was introduced because at that time many existing plants in Austria were in a sustainability crisis. The QM Heizwerke quality requirements and guidelines demonstrably increased plant and resource efficiency and thus ensured technical, economic and ecological sustainability. The current strong increase in demand for regional and price-stable heat supply is again leading to a boom in biomass district heating. On the one hand, this accelerates the renewable heat transition, but on the other hand, it requires compliance with the quality criteria defined by QM Heizwerke more than ever, in order to avoid repeating old mistakes and to secure plant expansions economically and ecologically in the long term.

An essential strategy is to have experienced and trained quality managers (QBs) accompany a biomass district heating project from the start of planning to operation and optimisation of the plants. The basic principles and the process flow of the QM system are laid down in a series of publications of the international working group QM for Biomass DH Plants (QM Holzheizwerke® - ARGE QMH). In Austria, the projects and the implementation of the QM system are recorded and handled in the QM database, to which all project participants have access as part of the funding process. In addition, operating reports of the plants are collected over several years. This treasure trove of data enables anonymous evaluations that provide important information on the current status of biomass district heating in Austria, as well as inputs for the further development of the QM system.
QM Heizwerke also works on the dissemination of information as well as measures and tools to support the district heating sector and the heat transition. In addition to possibilities for spatial energy planning as a basis for the sustainable expansion and densification of district heating, the use of alternative heat sources and the future role of biomass, for example in industry, will also be highlighted. For example, work is currently underway on a measure for GIS recording of existing biomass district heating networks to support spatial energy planning. As part of the consulting offered by QM Heizwerke, older plants are evaluated free of charge and advised on their way into the future. Work is also being done to disseminate the successful QM Heizwerke model internationally.

Current evaluations of the QM database show steady, measurable successes. The average network losses of biomass district heating networks are decreasing, while at the same time connection densities are increasing and planning reliability is improving.
The QM Planning Handbook was completely revised in cooperation with ARGE QMH, expanded with regard to the integration of alternative renewable heat sources and is now available free of charge. In Italy in particular, great successes were achieved in terms of internationalisation. In the Friuli Venezia Giulia region, there is a new full member of the international ARGE QMH since 2021 and also the first active Italian QBs were trained by QM Heizwerke.
The consistent implementation of the quality standards defined by QM Heizwerke is necessary to ensure the long-term success and efficiency of Austrian biomass district heating systems in the future and to make the best possible use of the existing biomass potential.

Active flue gas condensation with absorption heat pump –experiences, new concepts and potentials

Harald Schrammel, Harald Blazek. Michael Barnick
StepsAhead Energiesysteme GmbH
Meranasse 84, A-8010 Graz
h.schrammel@stepsahead.at
https://stepsahead.at/

Biomass is one of the most important renewable energy sources and according to current energy strategies, its utilisation for heat and electricity production, renewable fuels and material use will be further increasing. To meet these expectations, the available biomass resources must be used with the highest possible efficiency. By combining absorption heat pumps (AHP) with flue gas condensation units for biomass CHP plants, the overall efficiency is significantly increased and up to 40% more energy output is achieved from the same amount of fuel.

Heat recovery with economiser (sensible heat) and flue gas condensation (sensible heat + latent heat of wet flue gas) are installed downstream of biomass boilers to increase the overall plant efficiency. Heat recovery by means of passive flue gas condensation is limited by the return temperature of the heat sink (e.g. heat network). Thus, the heat recovery rate is max. 10-15%. Integrating an AHP leads to an active flue gas condensation system operated at significantly lower temperatures which leads to lower flue gas temperatures and heat recovery rates >30%.

Like conventional heat pumps, AHPs can raise heat from a lower to a higher temperature level. But they are driven by high-temperature heat (typically up to 150°C) and an absorption/desorption cycle using water as refrigerant and a LiBr-water solution as solvent. Hence, instead of expensive electric power the heat produced by the biomass boiler can be used as driving energy to recover otherwise unused low-temperature heat from the flue gas by lifting its temperature. While doing this, the driving heat is not lost, but can still be used together with the recovered heat, for example in a district heating network. This significantly increases the heat output and the overall plant efficiency without additional fuel demand.

Several high-efficiency plants with absorption heat pumps and active flue gas condensation have already been implemented. Operating data of the plants show that flue gas temperatures in the range of 20°C and heat recovery rates up to >40% are achieved. The plants are characterised by very low maintenance costs, very low consumption of operating resource and a long service life.

StepsAhead has developed and implemented a wide variety of technical concepts for single and multiple boiler plants as well as biomass CHP plants. Special attention was paid to individual design, optimal plant integration adapted to the respective conditions and a special control concept for the AHP to maximise the yield in different load conditions. StepsAhead has developed a new system concept in which driving heat of 105°C is sufficient. This can be provided by conventional biomass boilers. Hence, no upgrade or reinvestment costs for high temperature boilers are required and it reduces operation costs since less strict legal requirements apply. This development was made possible by detailed analysis of the internal processes of the AHP and the creation and validation of a detailed physical model of the absorption and desorption process as basis for carrying out comprehensive simulations of the entire plant. This innovative concept allows an easier integration of AHPs into biomass heating plants and is especially interesting for existing or smaller plants. The disadvantage is a lower yield, which is compensated by lower costs for boiler, integration and operation.

High-efficiency biomass CHP plants with AHPs and active flue gas condensation represent the state of the art in technology and efficiency. The systems are proven under real operating conditions and are increasingly implemented in biomass heating plants from approx. 3 MW up to large-scale power plants.

Climate impact of small-scale biomass combustion plants calculated based on real measurement data from the TFZ

Robert Mack

Technology and Support Centre (TFZ) in the Centre of Excellence for Renewable

Resources, Schulgasse 18, D-94315 Straubing

Robert Mack: Tel.: +49 9421 300-154, E-Mail: robert.mack@tfz.bayern.de

www.tfz.bayern.de

Co-Authors: Claudia Schön, Dr. Hans Hartmann

The energetic use of biomass for heat generation in private households is currently subject to strong criticism from the media, environmental organizations and politicians. As a result, society's acceptance of heating with biomass is increasingly declining. In addition to the discussion about particulate emissions from small-scale biomass furnaces (especially single-room heater, SRH), the climate neutrality of wood as a fuel and the sustainability of forest management are increasingly being called into question. In this context, the so-called "black carbon" (BC = elemental carbon contained in total dust) is often mentioned, which, according to current studies, could possibly have a very high greenhouse gas potential. To provide a fact-based basis for discussion in this increasingly intense debate, the TFZ used its own funds to conduct a study on the climate impact of small-scale biomass combustion systems and to make a comparison with fossil and other renewable heating systems.

For the study, real emission measurement data from the TFZ were used from a total of 6 log SRHs, one pellet SRH, one pellet boiler and one wood chip boiler. The measurements on the log-SRHs were performed according to a realistic test cycle ("beReal"), which also considers critical phases such as the start-up of the cold furnace. For the pellet SRH, measurement data with a total of 28, at the pellet boiler 8 ENplus certified wood pellet assortments and for the wood chip boiler forest residues, energy roundwood and wood chips from SRC were considered. For the greenhouse gas balance, only direct emissions of the components CH_4, N2O, VOC and BC were considered. Emissions of BC were determined directly at the TFZ for most of the investigated furnaces. Regarding CO_2 release from biomass combustion, a closed carbon cycle was assumed. GWP 100 values from the IPCC Report 2013 WG1AR5 were used to calculate CO_2 equivalents. In addition, upstream chain emissions generated during wood harvesting and fuel preparation were determined using in-house and external sources. For the log SRH, scenarios of faulty stove operation were also considered, and an estimate of climate-related improvements from the use of an electrostatic precipitator (ESP) was also considered. The 2020 emissions balance of renewable energy sources from the German Federal Environment Agency served as the source for the comparison with other heating systems as well as the respective upstream chain emissions of the fuels.

The results show significant differences in upstream chain emissions for logs (1.046 - 9.442 g/kWh) and pellets (10.215 - 31.680 g/kWh), depending on the database used. For wood chips from forest residues (15.684 - 16.560 g/kWh), the values are close to each other. The main reason for the deviations are the assumed boundary conditions. In general, it can be deduced from the results that heating with wood (as of today) has low GHG emissions compared to other heating systems (e.g. heat pump with current electricity mix), even taking into account the "Black Carbon"(BC) emission. For the single room heaters, it shows that BC can take a significant share (up to 80%) of the climate changing emissions. However, the uncertainty of the current GWP 100 is very high (CO_2 factor 100 to 1700). ESPs or primary-side optimization of new furnaces can significantly reduce or even almost eliminate dust and BC emissions. This serves both climate and health protection. Operator errors in log SRHs significantly increase GHG emissions. These can be significantly reduced by automatic combustion air devices. BC emissions from pellet SRH are highly fuel dependent, even if all fuels comply with ENplus-A1 requirements. Modern central heating boilers fueled with pellets or wood chips have almost no BC emissions anymore and thus perform best in the GHG balance considering the current electricity mix.

Donnerstag
19
Jänner

13:30–15:00 Uhr

ERA-NET Bioenergy

(Highlights der Bioenergieforschung Part II)

Länderübergreifende Bioenergieforschung im Rahmen der Bioökonomie: Stärkung der energetischen & stofflichen Nutzung biogener Rest- und Abfallstoffe

Thursday
19
January

01:30 pm–03:00 pm

ERA-NET Bioenergy

(Highlights of Bioenergy Research Part II)

Transnational bioenergy research within the framework of bioeconomy: Strengthening the energetic and material use of biogenic residues and waste

ERA-NET Bioenergy: Pulling bioenergy research together

Authors: *Carina Lemke,*
Organization: *Fachagentur Nachwachsende Rohstoffe e.V. (FNR)*
Address *Hofplatz 1, 18276 Gülzow-Prüzen, Germany*
E-mail Address *c.lemke@fnr.de*
Homepage *www.fnr.de*

Co-Authors: *Birger Kerckow*

Since 2000, the European Research Area (ERA) is the ambition to create a single, borderless market for research, innovation and technology across the EU. For the energy sector, the European Strategic Energy Technology Plan (SET Plan) supports the coordination of European and national clean energy research since 2007, bringing solutions from the lab to the market. Already since 2004 ERA-NETs have been the key instrument to practically improve cooperation and coordination of national and regional R&D support programmes in order to decrease the fragmentation of the European R&D landscape and thus to create a true, open ERA. Under Horizon Europe, European Partnerships are the new coordination instrument; the Clean Energy Transition Partnership (CETPartnership) launched in May 2022 has the focus on the whole energy sector.

ERA-NET Bioenergy started in October 2004 as an EU-funded project under the 6th Framework Programme with founding members from Austria, Finland, Germany, The Netherlands, Sweden and United Kingdom, aiming to enhance European research cooperation and coordination in this field by way of networking of the relevant R&D programmes of national governments. Since January 2011, ERA-NET Bioenergy is a self-sustained network with a clear focus on joint calls for R&D proposals with funding based on national programmes. This way, the network fills a specific gap in R&D funding: its Joint Calls cover topics in which transnational cooperation is essential or bring significant added value, but which are not addressed by the European Research&Innovation Framework Programmes (FP). Consortia are supported which contribute to innovation, knowledge transfer and mobilisation of researchers, but which would have been too small for the FP, or lacked the resources to apply.

So far, the ERA-NET Bioenergy network has launched 14 Joint Calls for proposals, usually one per year, funding over 60 transnational projects. Joint Calls with other ERA-NETs (WoodWisdom in 2010, BESTF3 in 2017, 2018, and 2019) allowed widening the thematic perspective and enlarging the network of funders and researchers/applicants. The latest calls focused on Bioeconomy. By way of these calls, ERA-NET Bioenergy strengthens national bioenergy research programmes by enhancing co-operation and co-ordination between the ministries/agencies. Through collaboration, the individual national programmes produce higher-quality results, while through coordination; they complement each other, avoiding duplication. From industrial and academic side, the value of the cooperation has been acknowledged and is seen as a vital additional tool for European cooperation on a medium-scale level. The cooperation has resulted in quality improvements and cost reductions of research by bringing together especially SMEs and research institutes from different countries.

ERA-NET Bioenergy is a stable initiative, providing a great opportunity to funding of consortia from the current partner countries: Austria, Switzerland, Germany, and Poland. Due to strong links to Sweden, the Netherlands, UK and Finland, more international calls are possible as well. Partners of the ERA-NET Bioenergy are involved in other European/international-level activities such as the IEA Bioenergy Technology Collaboration Programme, and at the same time, they are responsible for national programmes and/or policy making/decision support. Such bridges between European and national level are increasingly important in the area of bioenergy, as technologies move towards demonstration or early commercial stage, and projects reach scales that require joint efforts of the EU and Member States. ERA-NET Bioenergy welcomes interest from funding agencies from other countries to participate in the network as well!

The presentation will highlight key achievements of the network and give an overview of the results so far.

The authors are indebted to all current and past partners of ERA-NET Bioenergy for their active involvement and support, which are the reason why the project could become a success.

BioHEAT

Kuba, Matthias Corresponding author: Matthias.kuba@best-research.eu and
Fürsatz, Katharina BEST Bioenergy and Sustainable Technologies GmbH, Inffeldgasse 21b, 8010 Graz, Austria
Benedikt, Florian and Hofbauer, Hermann Inst. of Chemical, Environmental and Bioscience Engineering, TU Wien, Vienna, Austria

This project proposes a complete assessment of a sustainable **bio-refinery** process based on the gasification of so-called opportunity fuels (mostly biogenic fuels with low or negative fuel prices) into **heat** for industrial processes. This can either be achieved by direct combustion of the product gas in gas burners (e.g. rotary kilns) or by upgrading it into bioSNG (synthetic natural gas) for injection into the gas grid for subsequent industrial use. Through the utilization of dual fluidized bed (DFB) steam gasification as conversion technology, a product gas of medium calorific value can be generated. **Sector-coupling** with renewable electricity generation (e.g. wind power) and subsequent H_2 production via electrolysis will embed the process into a more holistic sustainable energy system by also being able to produce bioSNG.

In addition, through the upcycling of nutrient-rich ash residues from biogenic residues, an industrial intermediate feedstock for further recovery of valuables such as phosphorus and other nutrients can be gained, which leads to a **circular economy** for the nutrient cycle. The assessment of this complete process chain will be performed both experimentally and furthermore through a systemic techno-economic evaluation.

Opportunity fuels are unconventional fuels usually derived from a residue or by-product and are often of biogenic origin. Using biogenic residues or fuel blends of them as feedstock for heat production for industry is an important step towards a climate neutral industry. On the one hand, the utilization of biogenic residues enables additional feedstock potentials for the use in biorefineries. Biogenic residues are positioned at the end of the cascadic use of biomass and therefore of high relevance to thermal conversion processes. On the other hand, the use of biogenic residues is expected to improve the business case for such a process chain due to the comparably low or even negative fuel prices.

***Dual Fluidized Bed* steam gasification**
The thermochemical conversion of biogenic opportunity fuels (including residues) is a promising option to enable the eco-friendly and efficient production of heat (either directly or via bioSNG) and to recover nutrients from the ash. The development of the technology also benefits other biorefinery routes, such as the production of biofuels and chemicals. Thus, the product range gained from the utilization of opportunity fuels increases significantly compared to conventional combustion. DFB steam gasification of woody biomass is a technologically-proven process to produce nitrogen-lean product gas with a heating value of around 12-14 MJ/Nm³.

This technology was first demonstrated in industrial-scale in the 2000s based on woody-biomass as fuel and electricity as main product. Today's shift towards cascadic use of biomass and the necessary development of bio-based economies leads to a second generation of the technology: waste conversion and upgrading of the product gas into valuable products become the main topics of interest. Since opportunity fuels have never been used as fuel in commercial DFB steam gasification, the development needs to be done from pilot- and demo-scale, which is proposed in this project, before engaging in further upscale to commercial scale. When using opportunity fuels with higher contents of fuel ash, attention also has to be given to the influence of the ash on the gasification reactions. Therefore, special focus is given to the evaluation of bed material surface composition (which changes due to interactions with fuel ash) and its influence on catalytic activity. Additionally, the accruing ash will also be evaluated as an additional product. Due to the high content of valuable nutrients in many opportunity fuels, the will be investigated towards its suitability as fertilizer.To further develop the gasification technology a variety of on-line measurements will also be developed throughout the course of this project. The newly developed fibre optics measurements will allow for a more detailed monitoring of gasification operation (e.g. water content, gaseous carbon containing compounds, etc.) which will allow a further optimization of gasification operation.

Bio-refinery for heat production and recovery of nutrients
Due to the versatility of the technology, biorefinery concepts based on DFB steam gasification are a sustainable way of flexibly adapting to changing markets and political circumstances. In this project, three main objectives will be investigated:

- **Heat production:** The product gas gained from DFB steam gasification can be used for direct combustion in gas burners or upgraded through methanation into valuable bioSNG. Direct injection into the gas grid allows for heat production in industrial processes from bioSNG used as intermediate energy carrier.
- **Circular economy:** Besides the product gas, also the solid ash residue, which in the case of opportunity fuels is rich in a variety of valuable nutrients (e.g. phosphorus), can lead to an additional product – an industrial intermediate feedstock for the recovery of nutrients leading to a circular economy.
- **Sector coupling:** Embedding the process chain into a more holistic sustainable energy system increases the output efficiency through inclusion of external hydrogen (from e.g. wind power and subsequent electrolysis). An overall economic and ecologic assessment and process simulation of the full process chain will be included for further upscaling of the concept.

Valorisation of industrial residues for a sustainable industry (ERA-NET project VARESI)

DI Mag. (FH) Wolfgang Gabauer; University of Natural Resources and Life Sciences; Institute of Environmental Biotechnology; wolfgang.gabauer@boku.ac.at

Univ.Prof. Dipl.-Ing. Dr.techn.Christoph Pfeifer; University of Natural Resources and Life Sciences; Institute of Chemical and Energy Engineering; christoph.pfeifer@boku.ac.at

Dr. Hajo Nägele; ZHAW Zurich University of Applied Sciences, ICBT Institute for Chemistry and Biotechnology; hajo.naegele@zhaw.ch

Dr. Anton Scentic; ZHAW Zurich University of Applied Sciences, Institute of Sustainable Development; hajo.naegele@zhaw.ch

DI Johanna Bogner, AAT – Abwasser- und Abfalltechnik GmbH; johanna.bogner@aat-biogas.at

Dipl.-Ing. Gunther Pesta; Atres – Anaerobtechnik Regenerative Energiesysteme; pesta@atres-group.com

Themenbereich: Biomasse und reststoffbasierte Bioraffinerien

The operational work of the ERA-NET Bioenergy project VARESI started in 2nd half of 2022. The aim of the project is to valorize organic industrial residues to produce energy and value-added products by a zero-waste process. Products are biogas as energy carrier, hydrochar (from hydrothermal carbonization, HTC) for CO_2 sequestration or soil enhancement and recovered process water. The studied industrial sectors are the pharmaceutical industry, paper industry and selected food industries such as dairies, beverage industry, sugar production and slaughterhouses. The organic residues of these industries have high potentials in terms of both – materials and energy. The energetic utilization of industrial residues through anaerobic fermentation is state of the art and established on the market, but barely implemented in mentioned industries. There are 6 objectives of the VARESI project:

1. Valorisation of organic residues from industry to production of biogas, hydrochar and process water
2. Energy production from organic residues onsite the production plant to avoid transportation
3. Zero waste concept for industrial processes that includes a water treatment and recovery system
4. Optimal integration of energy in the industrial process to optimize the heat flows
5. CO_2 neutral production processes by replacing fossil fuels and reduction of energy demand
6. Process evaluation: Socio-technical benchmarking of the process with state-of the art concepts

First the anaerobic digestion step, then the treatment of the digestate with a membrane implemented HTC and finally another anaerobic treatment of the liquid product stream of the HTC will be investigated. The HTC is a procedure where hydrocarbons are produced under elevated pressure and temperature from many different organic material streams, especially those with high water content (e.g. digestate, sewage sludge). Dehydrogenation and carboxylation processes produce high-quality hydrochar which can be used e.g. as soil additives/fertilisers. However, the liquid fraction after HTC represents a non-negligible by-product of the process and represents a major obstacle for successful industrial application of the HTC process. This liquid fraction contains up to 15% of the initial organic load containing long and short chain fatty acids, significant amounts of inorganic nitrogen, phenolic and further aromatic compounds, which partly originate from the raw materials or from breakdown and condensation and aromatization reactions during HTC treatment. Within the project the components of this process water will be analyzed and the degradation using different anaerobic digestion systems (batch, fluidized bed reactor, trickle bed reactor) will be investigated. First results are expected in the coming monts.

Up-Whey - Upstream processing of lactose whey for bulk chemicals and energy production

Michael Mandl[1], Marlene Kienberger[2], Paul Demmelmayer[2], Stefan Pflügl[3], Regina Kutscha[3], Angelo Gössi[4], Alan Pérez[4], Wolfgang Riedl[4]

[1] *tbw research GesmbH, Grünbergstr. 15, 1120 Wien, Email: m.mandl@tbwresearch.org*
[2] *TU-Graz, Institut für Chemische Verfahrenstechnik u. Umwelttechnik, Inffeldgasse 25C, 8010 Graz,*
[3] *Technische Universität Wien, Institut für Verfahrenstechnik, Umwelttechnik und technische Biowissenschaften, Getreidemarkt 9, 1060 Wien,*
[4] *Hochschule für Life Sciences FHNW, Institut für Chemie und Bioanalytik, Hofackerstrasse 30, 4132 Muttenz.*

The scope of the UP-Whey project includes the development and assessment of new technologies for valorising dairy wastes, in particular sour and sweet lactose whey for the sustainable production of chemicals such as (i) lactic acid (LA) and (ii) isopropanol. The focus of the lactic acid process is not on the fermentation, but on the development of an integrated lactic acid downstream process suitable for complex solutions using a membrane-supported liquid-liquid extraction approach. The fermentation process for producing isopropanol is designed to be robust to directly valorise typical dairy waste side streams to avoid further pre-treatments. Works also include downstream processing to separate isopropanol at high concentration and quality. Developed processes are used to define scenarios for system integration into a whey biorefining. Technology scenarios will be assessed from a technical, economic (prefeasibility) and environmental (LCA) perspective. The assessment also includes the production of biogas (power & heat) from whey as a reference scenario, results of UP-Whey will hence give a clear status on product and energy scenarios for utilising dairy wastes. Presentation provides a status of work and interim results of process developments with a clear focus on lactic acid and isopropanol.

The investigation of a membrane supported liquid-liquid extraction for LA involved a solvent screening, the calculation of mass transfer based on a rigorous model, the evaluation of the main operating conditions (flow rate, membrane area, flow direction and temperature), and the implementation of a subsequent back-extraction step [1&2]. Commercial PTFE capillary membranes were used due to its chemical stability and ease of cleaning [2]. A solvent phase consisting of tri-octyl-amine (TOA, 20 wt.%) and 1-decanol was used as base case and resulted in a high extraction efficiency. Green solvents, including deep eutectic solvents boosted the extraction efficiency by a factor of up to 10% [2]. In all cases LA was successfully removed from any feedstock, including a technical fermentation broth, without any crud formation. After back-extraction an aqueous LA-solution with a concentration of 8-10% LA was achieved. The obtained overall mass transfer coefficients were in the range of 1.5 - $2.5 \cdot 10^{-7}$ m/s and thus are in good agreement with typical values of membrane-supported extraction processes [3&4]. Further work will focus on optimizing the operating conditions of LA extraction with the PTFE membrane contactor, based on a sensitivity analysis combining modelling and experimental work. Further work will deal with the transfer of deep eutectic solvents to the membrane reactor and also the pre-treatment of sour whey.

Isopropanol fermentation process development included a screening phase to identify the “best producer” among several *Escherichia coli* ~~W~~ strains engineered for isopropanol production. After confirming its suitability for whey utilization, we assessed the strain performance in different bioprocess scenarios. Initial screenings in batch mode cultivations revealed the capability for the concomitant uptake of lactose, galactose and lactate contained in sour and sweet whey. Additionally, fed-batch and continuous approaches will be investigated and will allow the identification of key performance parameters. The subsequent determination of the optimal process mode will be done with regard to minimal feed pre-treatment, high productivity and low CO_2-yield. To allow for efficient downstream processing and to avoid accumulation of isopropanol up to inhibitory concentrations, possibilities of in situ product removal will need to be implemented. Eventually, the final process will be subject to economic and environmental evaluation.

Results on TEE -technical, economic and environmental assessment of whey biorefinery scenarios are expected to be available by July 2024.

[1] Chemical Engineering Science: X 13 (2022) 100119
[2] Separation and Purification Technology 241 (2020) 116694
[3] The Canadian Journal of Chemical Engineering, Volume 77, October, 1999
[4] Mass Transfer in Multiphase Systems and its Applications, IntechOpen, London. 10.5772/15276.

Profitable 2G-bioethanol plants – Parallel Use of Fractionated Lignin in Multiple Applications

Juha Ahola
University of Oulu
P.O Box 4300
FI-900014 UNIVERSITY OF OULU
Finland
E-mail: juha.aholai@oulu.fi

Anton Glieder[2], Johanna Panula-Perälä[1], Katharina Ebner[2], Ulla Lassi[1]
[1]University of Oulu, Finland, [2]Bisy GmbH, Austria

The PUMA project will increase the profitability of 2G-LCF biorefineries by enlarging the product portfolio in addition to main product bioethanol. PUMA will establish an innovative platform for identification and upgrading of lignin fractions by utilizing aromatic side streams in the most efficient and economical way. A major focus will be on catalytic conversion of so far untapped low molecular weight fractions. Mild/catalytic methods will be used for depolymerisation and refining in order to produce synthons for resins/polymers, composites, activated carbons/carbon foam and high-price bulk phenolics of broad and high industrial relevance and scale. For this, the PUMA consortium combines the essential expertise from biorefining, process design, industrial biotechnology and piloting in order to valorize an unused CO2-neutral source for energy carriers and value-added bio-based aromatics and products.

15:30–17:00 Uhr

Parallelblock 6

Emissionsarme und effiziente Verbrennung und Festbettvergasung

03:30 pm–05:00 pm

Parallel Session 6

Clean and efficient combustion and fixed bed gasification

Log wood stove licence – Emission reduction through training of log wood stove users

Claudia Schön
Technology and Support Centre in the Centre of Excellence for Renewable Resources (TFZ),
Schulgasse 18, 94315 Straubing, Germany,
claudia.schoen@tfz.bayern.de
www.tfz.bayern.de

Co-Authors: *Mirjam Müller (DBFZ), Hans Hartmann (TFZ)*, Tobias Ulbricht (DBFZ), Rico Eßbach (DBI), *Ingo Hartmann (DBFZ), Laurenz Hermann (co2online), Masha Wagner (co2online)*

Despite the use of renewable resources, log wood stoves often offer potential for discussion as to whether their use is still justified in terms of air pollution control and effectiveness. A major factor in real emissions is the operator of the stove. Due to wrong user operation, for example an incorrect decision regarding the installed heating capacity or the use of unsuitable fuel, emissions can be many times higher than the actual state of the art.

The reduction of these user-related emissions is being addressed by a project funded by the German Federal Environment Agency, in which the realization of voluntary training courses for stove owners is being prepared. The project started in November 2021 and will run until May 2023. Currently, both a concept for a municipal implementation and training materials are being prepared, which should enable the implementation of a three times two-hour training including an illustrative stove firing.

The concept includes instructions on various aspects of training implementation. In addition to the training procedure and the topics covered by the training material, the concept also specifies the resources required, ranging from the premises to demonstration materials. Potential contact persons with contact data are named for mandatory actors, e. g. instructors, as well as other partners, e. g. for the promotion of the offer. In addition, the concept provides options for local advertising as well as an initial cost estimate for both the initial implementation and ongoing costs for the establishment of a regular offer. In order to promote the actual implementation in the follow-up of the project, a regular exchange with relevant actors already takes place during the project in the context of discussions and workshops.

In terms of content, participants in the training courses will be provided with background knowledge to understand the current discussion on small combustion plants in relation to climate and environmental protection, as well as basic knowledge on the combustion process and legal information. The focus of the training materials is on advice on selecting a suitable stove, and the design and operation of a stove are explained. Essential here are the compiled recommendations for low-emission operation. At best, the firing can be carried out practically later during the training courses. Furthermore, background information such as legal requirements or aspects of air pollution control and environmental protection are addressed. In the context of the development of the training documents, presentation slides and background information for the later instructors will be created as well as information material for the later participants. In addition, a flyer to promote the training as well as a quiz and feedback questionnaires will be provided.

In November 2022, an evaluation of the created training material took place with six test persons, whereby the training success was evaluated by means of emission measurements during the operation of a stove before and after the training participation. For this purpose, feedback is obtained from the participants in order to identify options for improvement, which are still to be included in the documentation. After review of all documents by the client Federal Environment Agency, all documents are expected to be publicly accessible (open source) by the end of 2023.

Gasification of waste wood fractions in a fixed bed gasifier

Michael Kresta [1,2]
[1)] Josef Ressel Centre for production of activated carbon from municipal residues, Department for Environmental-, Energy and Process Engineering, Management Center Innsbruck
Universitätsstraße 15, 6020 Innsbruck
Michael.kresta@mci.edu
https://research.mci.edu/de/josef-ressel-zentrum

Co-Authors: Angela Hofmann[1], David Gurtner[1,2], Christoph Pfeifer [2]
[2)]University of Natural Resources and Life Sciences, Institute of Chemical and Energy Engineering, Vienna

Wood was and still is an important renewable raw material of native forests with versatile benefits. In terms of cascading use, multiple material use is preferable to energetic conversion. Wood as raw material is gaining in popularity in recent years, and with it the amount of resulting wood waste at the end of serviceability. This, as well as other municipal woody residues, represent a great potential for energy use and is preferable to landfilling. Current wood gas power plants primarily provide renewable energy in the form of heat and electricity using wood chips. Research on the use of waste wood at the cascade end in thermochemical gasification is scarce in the literature.
Thermochemical gasification of wood or woody feedstocks produces a gasification char as a byproduct, which is primarily carbon with a low ash content. The gasification by means of the staged floating fixed bed technology of the company Syncraft GmbH produces char from forest residues, which already reaches the quality of the European Biochar Certificate. In order to add further value to this by-product, the research centre "Josef Ressel Center for the Production of Activated Carbon from Municipal Residues" was founded. The main objective of the research centre is the utilization of municipal wood residues such as waste wood, tree cuttings, etc. (A I – A III) for the generation of electricity, heat and activated carbon.
The analysis of the potential and the properties of the new resource show significant differences between waste wood and wood chips from forest residues, the current standard material of Syncraft plants. This is due to different reduction methods. While wood chips are chipped, waste wood requires the use of shredders due to the high percentage of the impurities. Here, the needle-like shape of the waste wood particles is most problematic and requires adaptation of the process conditions and conveying technology. In addition, waste wood usually has a lower bulk density and a multimodal particle size distribution with a high proportion of fines. The chemical composition and physical properties also vary over a wide range due to aging effects and various pre-treatments, depending on the original use of the wood.
Experiments on autothermal pyrolysis by Nußbaumer and Gurtner show a lower mechanical stability as well as a smaller particle size of the resulting waste wood pyrolysis char. In turn, this leads to destabilization of the floating bed when it is integrated into the gasification reactor. Besides the gasification itself, the conveying technology is another limitation, since the needle-patterned structure is prone to bridging and clogging. This shows the importance of characterizing different waste wood fractions in terms of their suitability for the process. These investigations are focused on the wood processing achieving suitable particle size distributions.
Geometrical modifications of the gasification reactor and an adjustment of the process control become necessary. These modifications show a stable operation of the gasifier with waste wood achieving a constant gas quality. Further adaptations are aimed at a maximization of the calorific value of the resulting product gas, as well as the maximization of the fuel conversion and thus the product gas quantity.

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Efficiency increase of biomass combustion systems by a modular CO-lambda optimization: method and results from long-term verification

Christopher Zemann[1,2], Alexander Max[3], Markus Gölles[1,2], Martin Horn[2]
[1] BEST – Bioenergy and Sustainable Technolgies GmbH, Inffeldgasse 21b, 8010 Graz, Austria
[2] Graz University of Technology, Inffeldgasse 21b, 8010 Graz, Austria
[3] LAMTEC Meß- und Regeltechnik für Feuerungen GmbH & Co. KG, Josef-Reiert-Straße 26, 69190 Walldorf, Germany

Corresponding author: Markus Gölles, markus.goelles@best-research.eu

Introduction and motivation

A key objective for the operation of biomass boilers is to achieve the highest possible efficiency while emitting the lowest possible pollutant emissions. In order to automate this task, CO-lambda optimization methods have been proposed in literature that ensure that the biomass boiler is operated at the lowest excess air ratio at which no relevant pollutant emissions occur, maximizing efficiency as a result. Since this optimal excess air ratio depends on various external factors, such as fuel properties, CO-lambda optimization methods continuously incorporate new measurements of the excess air ratio and the carbon monoxide content of the flue gas and estimate a new optimal excess air ratio during operation.

While achieving promising results in lab-scale tests, none of the CO-lambda optimization methods presented in literature has yet been able to gain practical acceptance. Either they are not robust enough and provide inaccurate estimates of the optimal excess air ratio or they are too slow and do not allow the optimal excess air ratio to be tracked sufficiently quickly. With the goal of providing a method that is fit for practical application, this publication presents a new modular approach for CO-lambda optimization that determines the optimal excess air ratio robustly and quickly, i.e. in real time.

Method

The new approach for CO-lambda optimization approximates the correlation between the excess air ratio and the carbon monoxide content of the flue gas, the CO-lambda characteristic, with a continuous, algebraic, non-linear model function. For this purpose, it uses a recursive-least-squares algorithm to continuously identify the model function's parameters that lead to the optimal fit with the measured data, which are the excess air ratio and carbon monoxide content of the flue gas. From these model parameters, the optimal excess air ratio is calculated and defined as a desired value for the biomass boiler's existing controller. This existing controller then ensures, that the biomass boiler is operated with this desired optimal excess air ratio, thus, maximizing efficiency and decreasing pollutant emissions. As a result, this new approach for CO-lambda optimization is entirely modular and can be applied to any biomass boiler with an existing control strategy capable of accurately adjusting the excess air ratio. For the measurement of the carbon monoxide content of the flue gas, a separate sensor has to be used. For this study the commercially available and proven in-situ exhaust gas sensor "KS1D" provided by the company LAMTEC has been used.

Long-term verification

The new approach for CO-lambda optimization was tested and validated at a biomass boiler with a nominal capacity of 2.5 MW that supplies a local heating network and combusts wood chips with a water content ranging from 30 w.t.% to 50 w.t.%. The long-term validation took place over an entire heating period, i.e. 5 months from November to March, during which the biomass boiler was operated alternately with the new approach for CO-lambda optimization and the standard control strategy, which means a constant desired residual oxygen content. In total the new approach for CO-lambda optimization was active for 1155 operating hours while the standard control strategy was active for 1310 operating hours. Compared to the standard control strategy, the new approach for CO-lambda optimization increased the biomass boiler's efficiency by 3.8%, decreased total dust emissions by 19.5% and reduced carbon monoxide emissions on average (median) by 200 mg/m³. This demonstrates that the new approach for CO-lambda optimization is not only robust enough to run over a long period of time, it also leads to significant improvements in the biomass boiler's operation. In addition, following these results, this new approach for CO-lambda optimization has also successfully been implemented and demonstrated at another biomass boiler with a nominal capacity of 1 MW where it has already been active for several months. This contribution presents the new approach to CO-lambda optimization in detail and discusses its technological and economic impact.

Cost efficiency of renewable district heating systems: The case of Austria

Bernhard Mahlberg
Institute for Industrial Research and Vienna University of Economics and Business
Mittersteig 10/4, 1050 Vienna, Austria and Friedensplatz 1, 1020 Vienna, Austria
Mahlberg@iwi.ac.at and Bernhard.Mahlberg@wu.ac.at
https://iwi.ac.at and https://www.wu.ac.at/

Andrea Frank-Stocker, Wolfgang Koller

Heat generation based on conventional fossil fuels is considered to be the cause of a significant proportion of greenhouse gas emissions. Achieving the climate protection goals therefore requires a change to renewable energy sources such as biomass. Establishing renewable district heating systems is an important element of this transformation. These systems generate heat in a centralized location and distribute it through a network of insulated pipes for residential and commercial heating requirements such as space heating and water heating. In contrast to usual district heating, the transmission takes place via smaller, rural heating networks over relatively short distances. Another difference to usual district heating plants is that renewable district heating systems mostly obtain their fuel from suppliers in their own region.

Beside the need to achieve ambitious energy and climate policy goals there are various other reasons that justify a further expansion of biomass-based heating systems, such as security of supply, environmental compatibility, cost efficiency, social compatibility and competitiveness. Furthermore, the construction and the operation of biomass heating plants may create value added and jobs in the region, guarantee the income for farmers and foresters, strengthen rural areas as a space for working and living and enhance the formation of new enterprises.

Building on such systems is supported by public funding in many European countries. In order to ensure the success of these subsidies and economical use of the funds, an accompanying quality control is required in the planning, construction and operation of such systems. This results in a significant improvement in the technical quality and efficiency of the systems. A well-functioning and comprehensive benchmarking is essential for effective quality control.

This study expands the previously used benchmarking based on simple key figures by a new type of multi-variate approach based on efficiency estimates using Data Envelopment Analysis (DEA). The performance indicator calculated in this way takes into account all essential factors of production in renewable district heating systems simultaneously and estimates the cost-saving potentials of each individual plant examined. By decomposing cost efficiency into a technical and an allocative component, the causes of inefficiency are revealed. A subsequent regression analysis examines how plant-specific technical structural features and the regional environmental conditions of the respective plants influence their performance. Finally, the results of the regression analysis are used to work out the managerial inefficiency purged of the influence of structural peculiarities and operating environment. It is that part of the overall inefficiency that is due to the decisions of the operator and can therefore be reduced by changing the behaviour of the operator.

The novelty of this study is, firstly, that it only evaluates the performance of renewable district heating systems and does not compare heating plants of different fuel types. Strictly speaking, this satisfies the assumption of technological homogeneity of the examined objects in the DEA. Against the background of the current decarbonization efforts and the increasing use of renewable energy sources, this approach is more appropriate than comparing plants with each other that employ heterogeneous technologies as they use different fuels. Such comparisons, though also based on DEA, cannot indicate the potential for improvement at the plant level, because the structurally less productive technologies can never be as productive as the more productive ones. A second novelty is that only small-scale regionally or locally operating renewable district heating systems are examined, while previous studies investigate mostly large-scale district heating systems. The third innovation is the decomposition of cost efficiency into the components for technical and allocative efficiency of heating plants.

The applicability of the approach developed here is shown empirically using a sample of biomass district heating plants from Austria.

Small scale agri-gasification: gasifier plus engine prototype optimization

Topic: Electricity, heat and cold from biomass

Corresponding author:
- *Valerio Magalotti, Yanmar R&D Europe S.r.l., Viale Galileo 3/a, 50125 Firenze (IT). valerio_magalotti@yanmar.com*

Co-authors:
- *Roberto Mussi, Yanmar R&D Europe S.r.l., roberto_mussi@yanmar.com*
- *Lorenzo Pezzola, Yanmar R&D Europe S.r.l., lorenzo_pezzola@yanmar.com*
- *Luca Romani, University of Florence, luca.romani@unifi.it*
- *Sandro Raspanti, University of Florence, sandro.raspanti@unifi.it*
- *Lorenzo Bosi, University of Florence, lorenzo.bosi@unifi.it*
- *Giovanni Ferrara, University of Florence, giovanni.ferrara@unifi.it*

Fixed bed downdraft gasification technology is considered as one of the most efficient solutions for biomass thermochemical conversion in the field of micro and small-scale energy cogeneration. In fact, producer gas obtained through fixed bed downdraft reactors is usually characterized by low concentration of contaminants. The consequence is that it is possible to convert biomass into a producer gas through a relatively simple solution.

Despite the good gas quality that may be obtained thanks to this technology, a relevant work is still ongoing into the industrial and academic world to define reliable solutions that could guarantee a good control of the process and, consequently, a stable gas composition.

Yanmar R&D Europe, the European Research Center of Yanmar Company Ltd, a Japanese leading player as engine and machine manufacturer, has developed and installed a fixed bed – fuel flexible – micro gasification system designed for the valorization of different feedstock such as agricultural densified residues and woodchips. The pilot plant, installed in Italy in 2020, has been run for more than 1000h and it is designed to simultaneously generate 20 kWel and 40 kWth thanks to a cogeneration package made up of a customized Yanmar 4TNV98 unit. The original diesel based Yanmar engine has been modified to manage producer gas generated by the micro gasification system. Main modifications consisted of:

- Diesel injection system replacement with OTTO cycle ignition system
- Construction and installation of a specific and customized spark-holder (original)
- Compression ratio modification (to both prevent detonation and increase combustion chamber volume)
- Lubricating oil circuit modification to increase oil filtering capacity/capability

The goal of this work is to compare system performance (IMEP – Indicated Mean Effective Pressure, output power, biomass consumption), replacing the original spark-holder with a newly re-designed one. The gasification system is kept in the same steady state running conditions (control parameters, operating temperatures and pressure, biomass used) so the intrinsic variation of gas composition will not affect the system performance.

The experimental campaign is based on monitoring and recording both main gasifier system parameter and engine IMEP, via a dedicated DAq system, in three different engine set-ups:

- original spark-holder (four cylinders);
- re-designed spark-holder (one cylinder);
- re-designed spark-holder (four cylinders);

A final sum up will be reported on experiments performance comparison in terms of IMEP and output power, on engine side, and biomass consumption, overall system efficiency and producer gas LHV, on gasification system side.

Keywords: Biomass gasification, Downdraft, Fuel flexible, System optimization, Engine performance

15:30–17:00 Uhr

Parallelblock 7

Politik und Märkte

03:30 pm–05:00 pm

Parallel Session 7

Politics and Markets

Bioenergy: Learning from Experiences Retrospect, Status, Outlook

Manfred Woergetter
Retired (former occupation: BLT Wieselburg, Bioenergy2020+, BEST Research)
Am Kellerberg 49, 3250 Wieselburg
Manfred.Woergetter@outlook.com

The paper reviews my work from 1975 to 2019 on wood gasifier and vegetable oil for tractors, biofuels, biomass furnaces, bioenergy systems and renewable resources. Highlights of my work for the Federal Ministry for Agriculture, Forestry and Water Management have been the development of type test methods for small Biomass fired boilers, the market introduction of biodiesel, the management of the Ministry's "Renewable Resources Working Group", as well as national and international networking. Until the end of 2014 I also worked as site manager, key researcher and in the strategy board of the "Austrian Bioenergy Centre" (later "Bioenergy2020+, now BEST Research); in that time, I had the privilege to represent Austria in the Executive Committee of IEA Bioenergy on behalf of the Austrian Federal Ministry for Transport, Innovation and Technology (now Federal Ministry for Climate Action, Environment, Energy, Mobility, Innovation and Technology).

Renewable electricity from hydropower was first addressed in Austria in 1883. In 1919, 4 Danube power plants have been considered; construction of the 1st one (Ybbs-Persenbeug) started in 1936. The Kaprun storage hydropower storage plant was initiated in 1928, and finished in 1955.

Since the 1950s, nuclear power was an issue, three power plants have been planned. A referendum in 1978 stopped this technology; since 1999, the constitution prohibits nuclear power in Austria. The occupation of the construction site of a new Danube power plant in the Hainburger Au in December 1984 also stopped the construction of an additional power plant on the Danube and subsequently triggered an environmental and democratic political change.

Until the 1970s, Austrian energy statistics only showed hydropower as renewable. According to a report of the Ministry for Agriculture and Forestry, firewood reached a low of 1.55 mio. m^3 (10.9 PJ) in 1973 already.

The oil crisis of 1973 showed the dependence of industrialized countries on fossil fuels, and the first efforts have been started to develop and install sustainable bioheat in Austria. Already in 1996, 220 biomass district heating systems have been in operation. The introduction of biofuels was also successful, leading to a direct CO2 reduction of 1.33 mio. t in 2020. With 231 PJ (53%), bioenergy is the number 1 renewable energy source today. However, Austria has lost some lead in GHG reduction over the last decade (1990-2020: Austria - 6%, EU 27+UK -34%).

The paper presents the development and the current status of bioenergy, addressing potentials, technologies, drivers, success factors and barriers. Conclusions & recommendations to Austria's policy makers are include. With biomass, a short-term and cost-effective switch from natural gas to bioheat seems to be possible. Rapid effects can also be realized with biogas as well as with classical and innovative transport biofuels. Austrian's leading position in technologies (e.g. in combustion, gasification as well as 1st and 2nd generation Biofuels) creates opportunities for exports.

A comprehensive system change is a global and highly complex issue that must also take into account the UN Sustainable Development Goals. In this context, I see people at the center of environment, economy and society. Innovative technologies are just as indispensable as scientifically sound work on external effects and social acceptance. The development of high-yield crops for energy and industry and the impact of land-use change are important, bio-based CCS and CCUS systems should also be addressed. Industry, business, and investors need a consistent, reliable, and long-term framework. Visions, strategies, implementation pathways, measurable targets, monitoring of development, and a supportive framework are in the hands of policy makers. Ambitious goals require effective and efficient use of limited (financial!) resources. The real successes can only be achieved in the markets where consumers make their own decisions.

Market Uptake Support for Intermediate Bioenergy Carriers - MUSIC project results

Dr. Rainer Janssen, Dominik Rutz
WIP Renewable Energies
81369 Munich, Germany
rainer.janssen@wip-munich.de
dominik.rutz@wip-munich.de
www.wip-munich.de

John Vos, Patrick Reumerman
BTG Biomass Technology Group
Josink Esweg 34, 7545 PN
Enschede, The Netherlands
vos@btgworld.com
reumerman@btgworld.com
www.btgworld.com

Dr. Konrad Siegfried, Linda König
Deutsches Biomasse-forschungszentrum (DBFZ)
Torgauer Straße 116,
04347 Leipzig, Germany
konrad.siegfried@dbfz.de
Linda.Koenig@dbfz.de
www.dbfz.de

Aim and approach used - The MUSIC project (www.music-h2020.eu) is a HORIZON2020 initiative that aims to facilitate market uptake of three types of **intermediate bioenergy carriers** (IBC's: torrefied biomass, fast pyrolysis liquid, and microbial oil) by developing **feedstock mobilisation strategies, improved logistics and IBC trade centres**.

Scientific innovation and relevance - Biomass, such as agricultural or forest residues, can be processed into energetically denser, storable and transportable intermediary products analogous to coal, oil and gaseous fossil energy carriers. IBCs may replace fossil fuels in the energy (power & heat) production sector, the transport sector, within energy intensive industries (e.g. steel production) and for the production of bio-based materials. IBCs contribute to energy security, reduce greenhouse gas emissions, and provide a sustainable alternative to fossil fuels in Europe.

The core actions in MUSIC include: Setting up **case studies** to determine the most cost-effective routes for biomass and IBC mobilisation. Evaluating **policy framework conditions, technologies, and markets** for IBCs. Involving, **engaging, and supporting stakeholders** by sharing knowledge on intermediate bioenergy carriers. Assessing **regional biomass flows**¸ using supply chain and optimisation software and tools. **Improving the trade** of IBCs both regionally and on EU level. Wider **dissemination** of project results and findings, including white papers on IBC **technology state of the art** and studies on **sectoral deployment perspectives**. Results of MUSIC will be **synthesised**, and **strategies and recommendations on supply chain development** will be developed based on the results.

Results and conclusions

Framework conditions (legal, institutional, and political) for market uptake of IBCs were evaluated and a first summary paper for policy makers, identifying promising applications of IBCs, was published.

Development of advanced and strategic case studies: Together with industries and market actors, and in four different regions (Greece, Italy, Nordic and pan-European) advanced case studies on value chain assessment and strategic case studies on expansion strategies and market uptake were developed. Together the set of eight case studies cover three types of intermediate bioenergy carriers. In this presentation the recommendations and lessons learned from the case studies are presented.

Spanning three case study regions (Greece, Italy, and Nordic), six **models for optimising logistics and minimising costs** of regional biomass supply for IBC production were expanded or newly developed.

Development of virtual trade centre: an interactive platform for mobilising feedstock towards IBC production and use was developed: the smart phone app tool BINTER. The application facilitates primary producers (Greek farmers) to declare available biomass, collectors/transporters to book the biomass they are interested in, and end-users to declare their preferences in biomass.

Strategies for biomass feedstock mobilisation and supply chain development are elaborated**,** based on extensive consultation of, and engagement with, stakeholders at various geographical levels (in case study region, national, and international) and **advice to policy makers (**at all levels) to serve as input for more informed policy, market support and financial frameworks.

The MUSIC consortium consists of sixteen partners from seven European countries: Sweden, Finland, The Netherlands, Belgium, Germany, Italy, and Greece. The partnership has strong industrial participation, comprising three industry-driven network organisations and seven industry partners, including Europe's leading IBC technology developers, and is capable to achieve broad relevance and transferability of all results in the European bioenergy sector.

Thermal upgrading by Torrefaction/Carbonization, a supply and demand side sector update

Michael Wild, President IBTC;

+43 676 6117622

email: michael@wild.or.at

http://biomasstorrefaction.org

Thermal upgrading of Biomass is seeing a second hype and this time it is driven from product demand in various markets. The sector, especially the technology providers have raised the temperature to high. An array of additional products, by products and additional processes is the result and is resulting in a much healthier sector than before.

The focus and dependence on the power market as only significant offtaker has caused plenty of troubles in the last decade for the sector. Now the trouble seems rather to ramp up fast enough processing capacity not to frustrate demand side.

- In the presentation an update on existing plants respectively plants in the pipeline around the globe will be provided.

Further topics discussed:

- Which sectors are currently demanding carbonized biomass and what are typical specifications.
- Dominant form factors for trade
- Feedstocks addressed and processed
- By-products of the thermal treatment

A brief excursion on the International Biomass Torrefaction and Carbonisation Council (IBTC) that became an independent association by January 23, its mission, the planned activities and the services offered to members and the markets shall conclude the presentation.

Production capacity and outlook for advanced biofuels worldwide

Andrea Sonnleitner
BEST – Bioenergy and Sustainable Technologies GmbH
Inffeldgasse 21 B, 8010 Graz, Austria
Andrea.sonnleitner@best-research.eu
www.best-research.eu

Co-Authors: Dina Bacovsky
Dina.bacovsky@best-research.eu

Reducing greenhouse gas emissions from the transport sector is a goal of national and international climate and energy policy, but is particularly difficult to achieve compared to other sectors. Biofuels are already making a significant contribution here, immediately reducing emissions from the existing vehicle fleet. Developing technologies to produce advanced biofuels from biomass and residues should enable expanded production and increased GHG emission savings in the transportation sector.

In the last years, demand and **production of advanced transport fuels** from biomass and other renewable feedstocks increased. In particular, several plants for the production of HVO, aviation fuel components and sustainable aviation fuels (SAF) have been built or are in the planning phase. There is also a trend towards diversification and combination of technologies.

For example, co-processing units and hybrid systems are being integrated in fossil refineries. Technologies producing fuels using a combination of biomass and electric power or green hydrogen are available. So-called biogenic waste streams and waste streams from non-biological origin are also increasingly being used for the production of advanced fuels. The focus in the coming years will lie on producing fuels for the **long-distance transport sector** (i.e., shipping, aviation, rail, and trucking), which is more difficult to electrify.

Conventional and advanced biofuels can be produced through various technological routes such as oleochemical, biochemical, thermochemical, and hybrid conversion technologies. The conventional biofuels are already commercially available and ready for the market. Advanced biofuels have been successfully demonstrated in different countries and the commercialization of different technologies progresses.

IEA Bioenergy Task 39 is observing the status and the development of demonstration facilities for advanced liquid and gaseous biofuels since many years and established a publicly available database and map. The database lists facilities producing advanced biofuels via different technology pathways covering gasification, fermentation, hydrotreatment, fast pyrolysis, hydrothermal liquefaction, lignin depolymerization and hybrid technologies with E-fuels.

The **IEA Bioenergy Task 39 database on demonstration facilities** for the production of advanced liquid and gaseous biofuels for transport ("demo plants database", https://demoplants.best-research.eu/) has been set up and is maintained by BEST since more than 12 years. Within this timeframe trends, successes, lessons learned and key issues for limitation became visible.

The observation of the development over time has shown that for some technologies the commercialization progresses and that there is capacity potential for the industrial supply of drop-in advanced biofuels worldwide and in Europe.

Donnerstag
19
Jänner

15:30–17:00 Uhr

Parallelblock 8

Grünes Gas aus Bioraffinerien

Thursday
19
January

03:30 pm–05:00 pm

Parallel Session 8

Green gas biorefining processes

Utilization of biomass for high-purity hydrogen production with chemical looping

Bernd STOPPACHER
Institute of Chemical Engineering and Environmental Technology, Graz University of Technology
Inffeldgasse 25C
bernd.stoppacher@tugraz.at
https://www.tugraz.at/institute/ceet/research/hacker-group

Co-Author: Viktor HACKER

The upgrade of waste streams from agricultural and industrial processes to high-value energy carriers is an essential contribution to the transition towards a sustainable energy system. Biogas from the fermentation of biogenic residues provides a promising alternative feedstock for decentralized hydrogen production.
The Reformer Steam Iron Cycle (RESC) is a fixed-bed process based on chemical looping for the production of high-purity hydrogen from gaseous fuels [1]. In the research project Biogas$_2$H$_2$, a 10 kW$_{th}$ fixed-bed chemical looping laboratory system was coupled to a 3 MW$_{th}$ biogas fermenter in Mureck, located in the southern region of Austria. Thirty redox cycles were performed in the experimental study. The generated hydrogen was characterized online by ppm-range gas analysis and exhibited a product gas quality of up to 99.998%. Throughout a parameter study, the influence of relevant process parameters (temperature, O/R ratio, reduction time, amount of steam in the oxidation phase) on the hydrogen purity and system efficiency was observed [2].

In general, the utilization of biogenic gases implicates the introduction of harmful sulfur contaminants in the process. Previous investigations in laboratory scale showed that hydrogen sulfide in the feed gas causes significant contamination of the product hydrogen and a performance loss of 12% in case of 100 ppm in the reductive feed gas. The reason was found in molecular chemisorption of H_2S on the surface of the oxygen carrier throughout the reduction phase. In the subsequent steam oxidation phase hydrogen sulfide desorbs again and enters the product gas stream [3].

The results of the project Biogas$_2$H$_2$ proofed that coupling fixed-bed chemical looping systems to biogas plants enable fuel cell grade hydrogen production and an economically competitive option for upgrading local available biogenic residuals to high-purity hydrogen.

Acknowledgements

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Upgrading of producer gas from small scale biomass air gasification: hydrogen yield enhancement over a char bed reactor

Francesco Patuzzi
Free University of Bozen-Bolzano, Faculty of Science and Technology, Piazza Università 5
39100 Bolzano, Italy - francesco.patuzzi@unibz.it

Co-Authors: Stefano Piazzi, Daniele Antolini, Lorenzo Menin and Marco Baratieri

A sustainable decarbonized energy system would require a considerable amount of renewable liquid and gaseous fuels to support applications where full electrical systems are ineffective or prohibitive. One of the most promising thermochemical methods for converting lignocellulosic feedstocks to a flexible synthetic gas that can be further processed into a variety of fuels and chemicals is biomass gasification. However, with reference to hydrogen and biofuels availability, biomass gasification has a number of technological hurdles, including a shortage of reducing equivalents accessible in the form of hydrogen, which are necessary for the synthesis of high energy density drop-in fuels. Low hydrogen concentration is especially troublesome in gasification systems that rely on partial internal combustion to meet the enthalpy needs of the gasifier, such as air gasification.
The goals of this study were to test the operation of a producer gas reforming unit at various temperatures and steam-to-syngas ratios and evaluate: 1) the relative increase in hydrogen concentration and yield compared to standalone air gasification, 2) the achievable rates of char carbon conversion, and 3) the compatibility of the obtained syngas compositions with the stoichiometric ratios required in the synthesis of various biofuel types. A comprehensive set of experiments was conducted using a small pilot-scale open top air gasifier (OTG, int = 13 cm) operated with biomass pellets and coupled to a producer gas allothermal reforming reactor (GRF, int = 14 cm) filled with char produced by the OTG, heated by an electrical split-furnace, and fed with a steam generator.
The experiments were conducted at temperatures of 700 °C, 750 °C, 800 °C, and 850 °C and the reactor was operated at different steam flow rates and residence times. The GRF was firstly tested without char and steam. Then, flowing the producer gas, the GRF was tested: a) without char but with steam, b) with char but without steam, and c) with both char and steam.
The producer gas composition exiting the OTG was in average (vol.% wet basis) H_2 16.0 % , CO 17.7 %, CO_2 14.5 %, CH_4 2.9 %, N_2 46.0 %, H_2O 2.9 %, with an average char yield of 0.10 $kg_{char}/kg_{biomass}$, and a hydrogen yield of 18.1 $g_{H2}/kg_{biomass}$. The reaction of the producer gas CO_2 with the carbon available in the char bed (Boudouard reaction) increased the CO fraction, which, in turn, reacted with steam to increase the hydrogen content, through the Water-Gas-Shift reaction (WGS). This reactions pathway was favored or not depending on the operating conditions. The results of the experiments showed that an increase in hydrogen concentration occurs while increasing the temperature and the steam flow rate. The highest values obtained at similar residence time and steam flow were (vol.% wet basis) 36.6 %, 38.6 %, 45.6 % and 47.0 %, at 700 °C, 750 °C, 800 °C, and 850 °C, respectively. However, the hydrogen yields did not follow the same trends, due to the decreasing rate of the WGS at higher temperature, which is opposite to the Boudouard reaction. As a matter of fact, the highest H_2 yield of approx. 50 $g_{H2}/kg_{biomass}$ was achieved at 750 °C, which represents the optimum temperature among the investigated ones in terms of hydrogen production. This work indicates an alternative option to produce hydrogen-rich syngas from air gasification.

First results of mass and energy balances of a 1 MW advanced dual fluidized bed steam gasification demonstration plant

David Kadlez

Vienna University of Technology, Institute of Chemical, Environmental and Bioscience Engineering

Getreidemarkt 9, 1060 Vienna, Austria

david.kadlez@tuwien.ac.at

https://www.tuwien.at/en/tch/icebe/e166-07/research-unit-industrial-plant-engineering-and-application-of-digital-methods

Co-Authors: Florian Benedikt, Alexander Bartik, Stefan Müller, Hermann Hofbauer, Thomas Karel, Matthias Binder, Miriam Huber, Anna Egger, Daniel Hochstöger, Katharina Fürsatz, Matthias Kuba

The advanced dual fluidized bed (DFB) gasification technology allows to generate medium-calorific product gas from various feedstock. Thereby, biogenic residues, municipal and industrial wastes e.g. sewage sludge or rejects from pulp and paper industry can be utilized. The varying chemical properties of these feedstock pose a challenge not only to the DFB reactor system, but also demand improved gas cleaning of the generated product gas. Downstream gas cleaning and a Fischer-Tropsch plant converts the product gas into valuable products such as Fischer-Tropsch diesel or waxes.

Over the last years, extensive research was conducted and over 50 fuels were tested on daily operation test runs in a 100 kW advanced DFB pilot plant at TU Wien. Based on the gained experience, a 1 MW demonstration plant was designed, built and commissioned, thus allowing the experimental gasification of various feedstock on a close-to-industrial scale. Investigating the feasibility of upscaling the technology with regards to product gas quality and operation parameters is the focus of the current test runs. In order to validate and verify the data from these campaigns, a process flow simulation using the software IPSEpro is conducted. This allows calculating otherwise immeasurable values such as mass and energy balances, heat losses and conversion efficiencies of chemical feedstock power into product gas power. This paper presents the results from these simulations to provide a comparison of different operating points for the feedstock wood chips Different temperatures, fuel loads, steam-to-fuel ratios and circulation rates, determine these operation points.

During test campaigns, wood chips were used for gasification. Input data for the simulation model consists of the plants distributed control system, fuel and bed material analysis, online gas analytics, and analytical results of wet-chemical tar, NH3, H2S, HCl, sampling. Key performance indicators for the demonstration plant include e.g. cold gas efficiency, water conversion, and product gas yield. Additionally, by the use of the simulation results, the fluidization regimes in the reactor system can be determined.

Results from the simulation allow drawing meaningful comparisons between design parameters, derived from 100 kW pilot plant operation and the upscaled 1 MW demonstration plant. This gives the opportunity to generate design values for industrial DFB gasification plants in the future.

Dual fluidized bed steam gasification of plastic rejects: Behavior of tar formation in a pilot plant with a counter-current column and flexible fuel input

Miriam Huber
BEST – Bioenergy and Sustainable Technologies GmbH
Inffeldgasse 21b, 8010 Graz, Austria
Miriam.huber@best-research.eu
www.best-research.eu

Co-Authors: Thomas Karel, Matthias Binder, Katharina Fürsatz, Daniel Hochstöger, Anna Egger, Matthias Kuba, Hermann Hofbauer

For the substitution of fossil fuels and thus the reduction of fossil carbon emissions, renewable gases obtained from residues or biomass are a key source of energy for industry and society. Dual fluidized bed steam gasification is a promising technology for renewable gas production, where residues are treated thermally forming a hydrogen-rich product gas that can be used for downstream applications such as FT synthesis, bio-SNG production or direct combustion in industrial processes.

In this research campaign, the gasification behavior of plastic rejects mixed with wood chips was investigated, with a particular interest in tar formation, as tars lead to deposits in downstream units and inefficient operation. The fuel input of 50 wt% plastic rejects is characterized by a relatively high water content of 40 wt%, which implies a high energy loss due to the required enthalpy of evaporation. Continuous operation was maintained for 24 hours, with regular measurements of the product gas composition, which contained up to 3.7 % C_2H_4, an indicator compound for tar concentrations. To mitigate the formation of tars, the pilot plant was designed with a counter-current column in the gasification reactor to improve the mixing and interaction of char and bed material. Variations of the solids-hold up in the counter-current column showed a dependence of tar formation and occurring tars species with increasing pressure drop along and over the entire column. A recommended mode of operations is given including the input of steam and auxiliary fuel to sustain a steady temperature and pressure profile in the reactors and a continuous product gas composition, irrespective of an inhomogeneous fuel composition.

Donnerstag
19
Jänner

15:30–17:00 Uhr

Parallelblock 9

Negative Emissionstechnologien auf Basis von Biomasse

Thursday
19
January

03:30 pm–05:00 pm

Parallel Session 9

Biomass-based negative emission technologies

CO_2 Storage in deep geological formations – options from the Austrian perspective

Holger Ott

Montanuniversität Leoben, Department Petroleum Engineering

Parkstraße 27, A-8700 Leoben, Austria

holger.ott@unileoben.ac.at

Co-author: Jakob Kulich, Montanuniversität Leoben

Geological CO_2 storage is a part of the Carbon Capture and Storage (CCS) technology chain. CCS allows for (a) the capture and long-term storage of CO_2 from industrial sources, thus preventing its release into the atmosphere, and (b) the direct capture from the air (from biomass or direct air capture) to achieve negative emissions. CCS is therefore considered a key enabler for decarbonizing CO_2-intensive industries and particularly for hard-to-abate emissions. The presentation gives a brief overview of the geological storage options and the underlying storage mechanisms. The resulting storage capacity and what makes us sure that geological CO_2 storage is safe are addressed in the presentation.

In Austria, there are several potential types of geological targets, including depleted oil and gas fields and deep saline aquifers. Furthermore, Austria has several large industrial CO_2 emitters located in close proximity to potential storage sites, making CCS a potentially viable option in the country. Although, CCS has worldwide been deployed on various scales, however, not to the required extent, in Austria a federal law prohibits the geological storage of CO_2 due to concerns on the grounds that technical and safety issues still had to be clarified and concerns regarding the environmental impacts and risks. The underlying evaluation report stated that further research is needed for permanent geological storage of CO_2, with a particular focus on national geological conditions and environmental impacts. Based on that the newly granted CaCTUS project will re-evaluate the potential for CCS in Austria according to state-of-the-art knowledge and methods in terms of storage mechanisms and safety as well as suitable geological conditions. Furthermore, potential capacities for CCS in Austria are gathered based on data material from Austrian rock formations and evaluated in a harmonized evaluation scheme.

09:00–10:30 Uhr

Parallelblock 10

Abfallbasierte Bioraffinerietechnologien für die Beschleunigung der Einführung und Umsetzung nachhaltiger Energieprozesse – Spezielle Session von WIRE Cost Action 20127

09:00 am–10:30 am

Parallel Session 10

Waste biorefinery technologies for accelerating sustainable energy processes – Special session of WIRE Cost Action 20127

Valorization potential for energy of *Arundo donax* biomass cultivated in heavy metal contaminated soils

Leandro Gomes lau.gomes@campus.fct.unl.pt *and Jorge Costa* jorge.costa@iseclisboa.pt

MEtRICs, Departamento de Ciências e Tecnologia da Biomassa, Departamento de Química, NOVA School of Science and Technology|FCT NOVA, Universidade NOVA de Lisboa, Campus Caparica, 2829-516 Caparica, Portugal;
Instituto Superior de Educação e Ciências, Alameda das Linhas de Torres 179, 1750-142 Lisbon, Portugal

Catarina Nobre
VALORIZA - Research Centre for Endogenous Resource Valorization, Polytechnic Institute of Portalegre, 7300-555 Portalegre, Portugal; catarina.nobre@ipportalegre.pt .

Paulo Brito
VALORIZA - Research Centre for Endogenous Resource Valorization, Polytechnic Institute of Portalegre, 7300-555 Portalegre, Portugal; pbrito@ipportalegre.pt .

Ana Luisa Fernando
MEtRICs, Departamento de Ciências e Tecnologia da Biomassa, Departamento de Química, NOVA School of Science and Technology|FCT NOVA, Universidade NOVA de Lisboa, Campus Caparica, 2829-516 Caparica, Portugal; ala@fct.unl.pt .

The utilization of *Arundo donax* (giant reed) can serve as a renewable and sustainable option to reduce the dependence on fossil resources. This crop can be used as feedstocks in different processes. Their versatility allows their utilization in biorefinery processes for biofuels, bioenergy, and bioproducts. *Arundo donax* can be used for bioproducts through incorporating its fibers in, e.g., composites or through the commercialization of their fractions (cellulose, hemicellulose, and lignin). *Arundo donax* can be used in biological, chemical, or thermochemical routes to produce different biofuels, such as ethanol, green gasoline, or heat and power. However, the cultivation of *A. donax* can compete with land needed for food production, incrementing the food *versus* fuel dilemma. Therefore, growing *A. donax* in contaminated land is a valuable option to reduce the problems associated with land use change. In addition, this option contributes to generating economic and environmental value for contaminated lands and allows the creation of direct and indirect jobs. Among the contaminants responsible for soil contamination, heavy metals represent a significant fraction that causes several damages to ecosystems, and when entering the food chain, they can cause several health problems. In this way, due to the capability of *A. donax* to adapt to several stressful environments, it is relevant to study the effect of different heavy metals and levels of contamination on the biomass yield and quality of *A. donax*. To achieve this goal, an experimental design was made with pots to test the effects of the single contamination of six different heavy metals (zinc, chrome, lead, nickel, cadmium, and copper) in *Arundo donax*'s biomass yield and quality. The chosen tested level for each heavy metal represents twice the limit established by Portuguese legislation regarding the heavy metal concentrations in alkaline soils (900 mg Zn kg^{-1}, 600 mg Cr kg^{-1}, 900 mg Pb kg^{-1}, 8 mg Cd kg^{-1}, 220 mg Ni kg^{-1}, and 400 mg Cu kg^{-1}). Control pots with non-contaminated soil were also essayed. The experiment has been conducted since June 2018 in the *Campus* area of the NOVA School of Sciences and Technology, Universidade NOVA de Lisboa, from where the rhizomes of giant reed were collected, to understand how this crop behaves in the long term. In this work, the aim is to present the results from the 3rd year. Preliminary results indicate that all contaminated trials affected *A. donax* yields. A significant reduction in Cd, Ni, and Cu trials, around 33%, 27%, and 28%, respectively, was observed. Chromium and Pb, however, showed the most toxic effects for *A. donax*, provoking a contraction in its productivity of 52% and 57%, respectively. The yield reduction caused by the contamination will affect the potential production of renewable energy and the associated greenhouse gas emissions reduction potential. Regarding the biomass quality, the proximate analysis did not appoint any difference in the volatile matter and fixed carbon among biomass harvested from contaminated and non-contaminated pots. The high heating value was also not affected by the presence of the contaminants. However, ash content increased in the biomass collected from the heavy metals-contaminated trials, a fact that can limit the application of the resulting biomass in thermochemical processes. The biomass's nitrogen and phosphorus content, fiber content, elemental analysis, and slagging and fouling indicators are still in progress.

A semi-detailed kinetic model for biomass pyrolysis and gasification: status, challenges and perspectives

[1]*Alessio Frassoldati**, [1]*Andrea Locaspi*, [1,3]*Paulo Debiagi*, [1]*Matteo Pelucchi*, [1]*Alberto Cuoci*, [1]*Tiziano Faravelli*, [1,2]*Veronica Piazza*

[1]*CRECK Modelling Lab, Department of Chemistry Materials and Chemical Engineering, Politecnico di Milano, Italy.*

[2]*Laboratory of Catalysis and Catalytic Processes, Department of Energy Politecnico di Milano, Italy.*

[3]*Simulation of Reactive Thermo-Fluid Systems, TU Darmstadt, Germany*

[*]*alessio.frassoldati@polimi.it*

Detailed kinetic modelling of biomass pyrolysis and gasification constitutes a fascinating but rather complex multicomponent, multiphase and multiscale problem. Starting from the complexity of an appropriate characterization of the biomass feedstock with the selection of reference species such as lignin, cellulose, hemicellulose and extractives, modelling the chemical dynamics of biomass in pyrolysis and gasification requires first to describe the degradation of the solid biomass, of condensable and non-condensable volatiles release and, second, their evolution in the gas phase. Indeed, secondary gas phase pyrolysis and/or partial oxidation reactions (gasification) must also be taken into account for a proper description of intermediate and product species release. The complex occurring chemistry unavoidably involves a huge number of species and reactions. Lumping techniques should be applied to enable the use of detailed/semi-detailed chemistry in reactor scale simulations while retaining the accuracy of the chemical description, ultimately allowing reactor design and optimization beyond currently adopted thermodynamic equilibrium approaches. Furthermore, beside gaseous and liquid products the model should also describe the heterogeneous formation of a solid residue (i.e. biochar) during pyrolysis as well as its partial oxidation for gasification conditions.

This work showcases and summarizes the outcomes of modelling efforts in the area of biomass pyrolysis and gasification performed at the CRECK Modelling Lab of Politecnico di Milano in the last 15 years of activity. In addition to a discussion of the underlying concepts, assumptions together with potentials and shortcomings of the chemical reaction engineering approach, this work presents a wide range validation of the integrated model in all of its different constituent parts. Outlooks for further works involving model extension and upgrade, full integration with the biochar module as well as possible couplings with semi-detailed kinetic model for solid plastic wastes available at CRECK.

References:

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Biomethane production from African fodder cane biomass cultivated in heavy metal contaminated soils

Barbara Rachele Ciaramella barbara.ciaramella@phd.unict.it and Elena Crapio elena.crapio@phd.unict.it
Dipartimento di Agricoltura, Alimentazione e Ambiente (Di3A), University of Catania, Via Valdisavoia 5, 95123 Catania, Italy;

Leandro Augusto Gomes
MEtRICs, Departamento de Ciências e Tecnologia da Biomassa, Departamento de Química, NOVA School of Science and Technology|FCT NOVA, Universidade NOVA de Lisboa, Campus Caparica, 2829-516 Caparica,Portugal; lau.gomes@campus.fct.unl.pt

Alessandra Piccitto alessandra.piccitto@phd.unict.it, Sebastiano Andrea Corinzia andrea.corinzia@unict.it, Salvatore Luciano Cosentino cosentin@unict.it and Giorgio Testa gtesta@unict.it.
Dipartimento di Agricoltura, Alimentazione e Ambiente (Di3A), University of Catania, Via Valdisavoia 5, 95123 Catania, Italy;

Biomass has become a promising alternative to reduce fossil resource dependence. However, biomass for energy purposes can represent a threat to food security due to the indirect land use change (iLUC). In this context, biomass cultivation in marginal lands contaminated with heavy metals appears as a suitable alternative for renewable and sustainable feedstock. Therefore, the biomass must be tolerant to contamination to be able to grow. African fodder cane (*Saccharum spontaneum* L. ssp. *aegyptiacum*), a perennial, rhizomatous lignocellulosic crop, has been proposed as an essential bioenergy crop for advanced biofuel production in the Mediterranean region. Due to the high tolerance of this crop to grow on marginal soils, under drought, salinity, and contaminated soils, African fodder cane appears helpful to reduce the competition between food and industrial crops for the use of land suitable for food or feed purposes. Phytoremediation uses selected plants with the ability to extract, stabilize or degrade pollutants from soil, and opens new challenges and opportunities in terms of economic prospects and environmental restoration. Using contaminated biomass as feedstock in anaerobic digestion to produce advanced biomethane seems to be a promising approach to valorize the biomass produced on contaminated soils. This research aims to assess biomethane production from African fodder cane biomass grown in soils contaminated with lead and cadmium. African fodder cane was grown in two different levels of soil lead contamination (450-900 mg kg^{-1}) and two different levels of cadmium contamination (4-8 mg kg^{-1}). During the annual dormancy after the growing season (February), the aboveground portion was harvested and weighed. The samples were ground and stored for chemical analysis after being oven-dried at 65 °C. Total solids (TS) and Volatile solids (VS) were measured. The BMP test was performed with an automatic methane potential detection system (AMPTS II, Automatic Methane Potential Test System, Bioprocess Control AB, Lund, Sweden). The experiment was conducted in reactors of 500 mL each, in which substrates and inoculum were mixed in a ratio of 1:3 in terms of grams of VS at mesophilic conditions (38 ± 1 °C) with continuous mixing. All tests were performed in three replications. The inoculum was initially obtained from an anaerobic digester located in Sicily and maintained in a reactor in the laboratory. To remove large, undigested particles, the inoculum was filtered through a 2 mm porosity sieve and then stabilized in a 38 °C incubator for 5 days. African fodder cane showed a great tolerance to grow in the presence of heavy metals in the soil. Whereas, the production of biomethane decreased at the increasing level of heavy metals in the biomass.

Biorefinery technologies integration in a biomass unit for bioenergy production and zero-carbon emissions/Title of speech

Charalambos Chasos
Department of Mechanical Engineering, Frederick University
7, Y. Frederickou Str., Pallouriotissa, 1036 Nicosia, CYPRUS
eng.cca@frederick.ac.cy
www.frederick.ac.cy

There is renewed interest for the wider use of biomass for energy production in the European Union, and this is directed towards the use of woody biomass for bioenergy with the aim to achieve net-zero carbon energy production. The main objective of the present work is firstly to provide an overview of the woody biomass use in the European Union with emphasis in local applications of woody biomass through distributed utilisation in Cyprus, with the examination of a local wooden-pellets unit. The second objective concerns the overview of the available biorefinery technologies that can be implemented in existing woody biomass production units, with the assessment of the combination of candidate biorefinery technologies with the operation of biomass production units. The third objective involves the investigation of the energy requirements and the carbon dioxide emissions produced by the operation of the local unit, along with the avoidance of carbon dioxide emissions by the produced pellets utilised for bioenergy production. The fourth objective is to provide a retrofit recommendation of the existing local unit with biorefinery technologies, in order to achieve a dual use of the wooden pellets for carbonisation and the production of syngas, the later to be exploited within the unit by examining internal combustion engines and gas-turbine technologies. These technologies are envisaged to generate electrical power, that can be used for the local needs of the unit and also to supply electricity to the national electricity grid of Cyprus. The methodologies used include firstly the technical assessment of the wooden-pellets unit and the candidate biorefinery technologies, which is performed by using the local woody raw material, the technical specifications, the production conditions for the unit industrial operation at the rural area of its installation. Thermochemistry methods are secondly used for the examination of the wooden-pellets, by using published data of the physical and chemical properties of the pellets for lean mixture combustion calculations in a furnace and the estimation of combustion temperatures and the resulting amount of carbon dioxide emissions, which are considered as avoidance since are created within a renewable energy source the biomass. Energy balance calculations are performed for the production unit combined with candidate biorefinery technology, in order to produce carbonised pellets and syngas for further utilisation in the power generation technologies, notably internal combustion engine and gas-turbine. Overall, the energy demands and the bioenergy produced by the unit are accounted for the electrical energy production, while the avoidance of carbon dioxide emissions is assessed. The present work provides recommendations for the upgrading of existing woody biomass installations with candidate biorefinery technologies, for bioenergy and power generation applications.

09:00–10:30 Uhr

Parallelblock 11

Digitale Methoden und Werkzeuge

09:00 am–10:30 am

Parallel Session 11

Digital Methods and Tools

Multiscale model development for biomass-based chemical looping processes

Thomas STEINER
BEST – Bioenergy and Sustainable Technologies GmbH
Inffeldgasse 21b, 8010 Graz
thomas.steiner@best-research.eu
https://best-research.eu/

Co-Authors: Kai SCHULZE, Robert SCHARLER, Andrés ANCA-COUCE

Biomass-based Chemical Looping (CL) processes constitute a promising alternative to traditional thermochemical conversion processes. Solid oxygen carrier materials are used as oxygen source instead of air and, thus, pure CO_2 is obtained at the outlet after the condensation of steam. When considering the additional CO_2-intake of biomass over its lifetime, such processes are called Negative Emission Technologies (NET), which are required in order to reach carbon neutrality until 2050.

The fuel biomass can, for example, be combusted (Chemical Looping Combustion, CLC), gasified (Chemical Looping Gasification, CLG) or used for hydrogen production (Chemical Looping Hydrogen, CLH). The detailed description of such processes calls for reliable models at multiple scales. At the smallest scale gas-solid reactions take place. They also predict the conversion of fine powders conveniently. In practical applications, however, not only powders but also particles/pellets are used. Transport phenomena around and into the particles then have to be considered in addition to heterogenous chemical reactions. At the largest process scale there are entire reactors, which typically contain high numbers of particles and give rise to additional transport phenomena.

Within the COMET project BIO-LOOP, experiments are conducted at all these process scales for selected oxygen carrier materials. The data obtained are then used for model development, aiming at describing the conversion at individual scales as well as holistic systems. A consistent methodology throughout all scales is developed in order to showcase the differences and influences of individual scales. In this work, an overview of the ongoing research within the model development sub-project of BIO-LOOP is provided. Thermogravimetric Analyses (TGA) of powders and single particles are conducted. Thus, a kinetic model can be developed and the additional transport resistance at the particle scale can be shown. In parallel, fixed bed experiments are conducted. They can be used for reactor model development as well as validation for the entire coupled model.

Application of flexible tools in Energy Intensive Industries

Author: **Nikolaos Margaritis**
Organization: Chemical Process and Energy Resources Institute (CPERI), Center for Research and Technology Hellas (CERTH)
Address: 4km N.R Ptolemaidas-Mpodosakeio Hospital area, 50200 Ptolemaida, Greece
E-mail Address: n.margaritis@certh.gr
Homepage: https://www.cperi.certh.gr/en/research-areas/solid-fuel-techonology-application-sector

Co-Authors: Christos Evaggelou, Panagiotis Grammelis, Haris Yianoulakis, Polykarpos Papageorgiou, Roberto Arevalo Turnes

The European Union, in order to reduce the catastrophic consequences of climate change, has greatly tightened the legal framework governing overconsumption and waste of energy. In this context, it is proposed to significantly reduce the use of fossil fuels and increase the use of green energy in all producing sectors. Of particular interest are the Energy Intensive Industries (EIIs) which represent 24% of the final energy consumption. The waste of energy with the simultaneous use of fossil fuels in the EIIs greatly increases the CO_2 emissions and their reduction must become a key goal. Part of the solution can be the substitution of fuel from carbon neutral fuels such as biomass, but also the upgrade of energy processes through technology advanced equipment.

The following paper presents, describes and analyzes two flexible model tools (CO_2 emissions/cost tool and CFD tool) that simulate the production process of an EII such as Grecian Magnesites (GM) and extract economic and technical conclusions regarding the substitution of fossil fuels (pet coke) with various types of biomass (such as Sunflower Husk Pellets, Olive Kernel and Sawdust). Production cost is reduced with biomass substitution at current CO_2 price (78.86 €/tn @27/11/ 2022) even for the most expensive type of biomass at high rates of substitution. As CO_2 price increases, the use of biomass seems an attractive alternative for this type of companies in order to remain sustainable. With prevailing pet coke price (350 €/tn) and biomass prices, replacing a part of fossil fuel with biomass is lucrative for GM. The higher the substitution, the higher the profit in both emissions and cost reduction. Initial results of this decision-making cost tool showed that the most profitable solution in economic terms is the 70% substitution, while the most beneficial type of biomass proved to be the olive kernel due to its low price and local availability. Furthermore, taking into account the general instability of the market stemming from various external factors (war in Ukraine, increase in fuel prices), the economic data extracted from the model are compared with those calculated one year ago. It is reported that the cost of production in GM increased by 34% during the last year, using only fossil fuels. The corresponding increase for biomass substitution is lower regardless of the percentage, while in the implementation of the optimal scenario (70% substitution with olive kernel), important cost savings can be achieved by the company. The 2nd simulation tool (CFD tool) was used to determine various functional characteristics of the production process and to determine the optimal operating conditions in GM. The realistic simulation of the combustion process inside the kiln predicts the changes in the operation conditions upon changes in the fuel blend. Thus, the distribution of temperature, gas composition or gas velocities can be determined in advance. This information allows the operators to decide if a given blend of biomass and coke is suitable from the point of view of magnesite production, as well from the point of view of emissions (CO_2 and NO_x) avoided.
For these predictions to be useful, it is necessary to have them available rapidly. To this end, from the CFD simulation, a reduced order model (ROM) has been developed that allows to run scenarios in real time, instead of the usually long times required by complex simulations. Comparative studies of fuel blend and biomass type can be carried out easily and rapidly, allowing to choose the most suitable substitution. The model predicted reductions in emissions (30% NO_x, 38% SO_x) in line with experimental values (21% NO_x, 47% SO_x), proving a valuable tool.

Optimizing the value of solid biomass-based (hybrid) systems in the context of the cellular approach

Dipl.-Ing. Lukas Richter
DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH
Torgauer Straße 116, D-04347 Leipzig
lukas.richter@dbfz.de

At the latest, since the 2022 energy crisis, the issues of supply security and resilience have become omnipresent. Without fossil fuels, Germany is dependent on a rapid expansion of renewable energies, which poses major challenges for the energy system. Volatile energy sources, such as wind and solar, are becoming the major pillars of the energy transition, but they themselves have only limited flexibility. For this reason, a decentralized use of solid biomass, together with heat pumps and heat-storages within hybrid systems, could play an important role. Rural areas in particular, where the possibility of a district heating network does not exist, are predestined for the decentralized use of solid biomass. However, this provision of energy by preferably small-scale producers instead of a few large power plants increases the variability as well as the complexity of the energy system. In order to avoid problematic power-grid conditions, these decentralized energy assets have to be managed properly, which leads to a high complexity in control and organization. A cross-sectoral organizational structure for this goal could be the so-called cellular approach.
In this context, a value-optimized combination of the cellular approach and solid biomass-based hybrid systems will be developed. The aim is to identify climate-friendly and cost-efficient solutions that offer a high level of supply security in both the electricity and the heating sectors. It will also be investigated whether and, if so, how the energetic use of solid biomass can provide a technologically and economically advantageous supplement for multivalent supply concepts.

In this study, a two-stage optimization approach is presented that considers the detailed modeling of hybrid systems along with the autonomous and subsidiary properties of the cellular approach. The first step of this approach is an investment optimization carried out with the Open Energy Modelling Framework (oemof). The basis of the modelling and optimization is a representative energy cell that reflects the building structure, weather and demand profiles as well as potentials for renewable energies in a rural area. This cell covers the area of a district and consists of several smaller cells at the building level. This results in a mixed-integer optimization based on cost efficiency, which is used to determine the optimal plant configuration and the scheduling for a calendar year depending on the specific constraints and scenarios. In order to model the cellular power system with sufficient accuracy and to be able to map flexibilities as well as possible limit violations, time steps of 15 minutes are used under the assumption of perfect foresight.
However, without a direct interaction of the energy cells, it is not possible to model the synergies of the cellular approach such as subsidiarity and increased autonomy. Therefore, the goal of the second stage is to find the operational optimum of each cell at the building level in order to generate a system optimum as the sum of the local optima. For this, an agent-based market model will be used to simulate the interactivity of each energy cell and optimise the operation towards cost-efficiency and subsidiarity.

With this two-stage optimization, it is possible to calculate the optimal plant configuration and operation for each cell over a period of one year. As a result, the use of solid biomass in decentralized supply concepts can be optimized and new insights can be gained into which plant concepts and operating schedules are to be preferred. In this way, the effect of locally available biogenic resources, whose potentials are limited, can be maximized. The focus of the planned presentation will be on the concept of a local market and the underlying rules of interaction as a foundation of the agent-based modelling, which will be applied on top of that.

Operational optimization and error detection in biomass boilers by model-based monitoring: methods and practice

Christopher Zemann[1,2], Helmut Niederwieser[1,2], Markus Gölles[1,2]
[1] BEST – Bioenergy and Sustainable Technolgies GmbH, Inffeldgasse 21b, 8010 Graz, Austria
[2] Graz University of Technology, Inffeldgasse 21b, 8010 Graz, Austria

Corresponding author: Markus Gölles, markus.goelles@best-research.eu

One of the main tasks for operators of medium- and large-scale biomass boilers is the continuous operational monitoring of these plants in order to assess their performance, detect errors and identify possibilities for operational optimization. However, due to the high complexity of this task, errors are frequently detected too late or not at all, which can lead to even more costly secondary errors. In addition, possibilities for optimization remain unused in many existing plants, resulting in unnecessary pollutant emissions and low efficiencies.

To assist operators in performing this task and to achieve a high level of automation, methods for the automated, model-based monitoring of such plants have been focus of recent research activities. In this contribution, we will discuss the numerous possibilities provided by the application of such methods in a practical context. For this purpose, we present selected results from previous activities, demonstrating how methods for model-based monitoring were applied at combustion plants and used to enable automated error detection and support operational optimization.

Exemplary result 1: We developed a soft-sensor which accurately estimates the non-measurable internal state of heat exchangers and implemented it at a large-scale combustion plant with a nominal capacity of 38.2 MW. This soft-sensor uses a dynamic mathematical model of the heat exchanger in combination with measured data to determine a new estimate for the heat exchanger's internal state every second. Based on this estimate, the soft-sensor accurately detects fouling and determines the non-measurable flue gas mass flow in real time. The estimated flue gas mass flow was used in a model-based control strategy which resulted in significant improvements of the combustion plant's operational behaviour and load modulation capabilities. These results are discussed in this contribution.

Exemplary result 2: We developed a method for the real-time estimation of non-measurable fuel properties, i.e. chemical composition, bulk density, lower heating value, in biomass boilers. These estimates were subsequently used in a model-based control strategy and enabled the improvement of the biomass boiler's fuel flexibility. Results of this estimator achieved for different biomass fuels, e.g. poplar wood chips, corncob grits and standard wood pellets, are discussed in this contribution.

On the basis of these selected results, it will be examined which possibilities arise from the use of methods for model-based monitoring in biomass boilers and also how these results can be extended to other technologies such as biomass gasifiers.

Freitag
20
Jänner

09:00–10:30 Uhr

Workshop

Thermische Veredelung von Biomasse durch Torrefizierung & Karbonisierung

Friday
20
January

09:00 am–10:30 am

Parallel Session 12

Thermal upgrading of biomass by torrefaction and carbonization

Abseits vom Holz: Alternative Biomasse zur Torrefizierung

Beyond Wood: Torrefaction of Alternative Biomass

Wolfgang Moser
NextFuel AB / NextFuel Technology Gmbh
Stockholm / Vienna
wolfgang.moser@nextfuel.com
www.nextfuel.com

Torrefizierung schafft die Möglichkeit, aus Biomasse einen vollwertigen Ersatz für fossile Kohle zu produzieren. Damit wird der Umstieg auf erneuerbare Energien in diesen Szenarien ermöglicht:

- wo auch in Zukunft die hohen Temperaturen eines Verbrennungsprozesses erforderlich sind (z.B. Zementherstellung);
- wo der Kohlenstoff im Produktionsprozess materiell erforderlich ist (z.B. Stahlerzeugung);
- wo es im Sinne der Nachhaltigkeit sinnvoll ist, die wirtschaftliche Lebensdauer einer bestehenden Anlage mit erneuerbaren Brennstoffen zu verlängern (z.B. Kohlekraftwerke).

Global betrachtet ist Holz nur in wenigen Regionen nachhaltig in sehr großen Mengen verfügbar. Im Industriebereich sind aber Projekte mit Millionen Tonnen Output erforderlich, um Ersatz für fossile Kohle zu schaffen. Außerdem gibt es für Holz eine solche Vielzahl an Nutzungsmöglichkeiten, dass auch die Wirtschaftlichkeit solcher Großprojekte schwierig zu erreichen ist.

Daher besteht besonderes Interesse an der Nutzbarmachung alternativer Rohstoffe (z.B. Elefantengras, Bagasse, Abfälle der agro-industriellen Verarbeitung...). Solche Rohstoffe stehen in vielen Regionen der Welt in nahezu unbegrenzter Menge und zu deutlich niedrigeren Kosten als Holz zur Verfügung. NextFuel hat bereits vielfach nachgewiesen, dass solche Rohstoffe auch im industriellen Maßstab zu torrefiziertem Brennstoff verarbeitet werden können. Wir geben in diesem Vortrag Einblick in die größten Potenziale und die wesentlichen Bedingungen zur Nutzung solcher alternativen Biomasse-Rohstoffe für den Ersatz fossiler Kohle.

Torrefaction creates the opportunity to produce a full replacement for fossil coal from biomass. This enables the switch to renewable energy in these scenarios:

- where the high temperatures of a combustion process are still required in the future (e.g. cement production);
- where carbon is materially required in the production process (e.g. steel production);
- where it makes sense in terms of sustainability to extend the economic life of an existing plant with renewable fuels (e.g. coal-fired power plants).

Globally, wood is sustainably available in very large quantities only in a few regions. However, in the industrial sector, projects with millions of tons of output are needed to create replacements for fossil coal. In addition, there is such a wide variety of uses for wood that even the economics of such large-scale projects are difficult to achieve.

Therefore, there is particular interest in harnessing alternative feedstocks (e.g., elephant grass, bagasse, waste from agro-industrial processing...). Such raw materials are available in many regions of the world in almost unlimited quantities and at significantly lower costs than wood. NextFuel has already demonstrated many times that such feedstocks can also be processed to torrefied fuel on an industrial scale. In this presentation, we will provide insight into the greatest potentials and the essential conditions for using such alternative biomass feedstocks to replace fossil coal.

Freitag
20
Jänner

11:00–12:30 Uhr

Parallelblock 12

Biomasse Brennstoff und Aschecharakterisierung

Friday
20
January

11:00 am–12:30 am

Parallel Session 12

Biomass fuel and ash characterization

Characterisation of waste wood for the use in floating fixed bed gasification

Angela Hofmann [1]
[1)]Josef Ressel Centre for production of activated carbon from municipal residues, Department for Environmental-, Energy and Process Engineering, Management Center Innsbruck
Universitätsstraße 15, A-6020 Innsbruck
angela.hofmann@mci.edu
www.mci.edu

Co-Authors: Sabrina Dumfort [1,2], Anna Szepannek [1,2], Christoph Pfeifer [2]
[2)]University of Natural Resources and Life Sciences, Institute of Chemical and Energy Engineering, Vienna

The popularity of wood as a raw material is increasing rapidly, and with it, the amount of waste wood. In Austria, around 1.22 million tons of waste wood and 4.22 million tons of wood residues accumulate annually. Most of the wood residues is used for the production of chip- and fibreboard, or for thermal recycling. The physical properties such as the size and shape of the input material and the mechanical stability are decisive for the utilization of waste wood in the floating fixed bed gasification process. There is hardly any literature or research on the properties of waste wood in thermochemical gasification. Above all, chemical changes or changes in strength properties due to the aging process of the waste wood, are not considered in detail in the literature. Hence, there is a great need to analyse the properties of old and residual wood.
In the course of a staged wood gasification plant, the pyrolysis char has to show a certain mechanical stability to ensure a sufficient gasification in the floating fixed bed reactor. Therefore, the pyrolysis process has to be investigated more closely. First investigations by Nußbaumer and Gurtner show a strong dependence of the mechanical stability of the pyrolysis coke on the pyrolysis conditions. A clear difference between waste wood and forest residue material (which is standard material in floating fixed bed gasifiers) could also be shown.
These investigations will be deepened with regard to the raw material properties. On the one hand, the focus is on investigations of chemical changes during the aging process of wood, in particular the degree of lignification of the raw material. Therefore, the chemical composition (lignin, cellulose, hemicellulose) of different waste wood samples is analysed by wet chemical extraction and subsequent HPLC analysis according to the standard NREL methods.
On the other hand, the thermal conduction behaviour in the raw material particle is also examined in order to be able to draw conclusions about the pyrolysis properties of the different input materials. For this purpose, defined sample cubes (old and fresh wood, hardwood as well as softwood) were prepared with thermocouples installed in the core and exposed to different pyrolysis conditions. The core temperature was logged and evaluated with regard to thermal conductivity, but also the exothermic behaviour during pyrolysis. These results show a clear difference between fresh and waste wood of the same type of wood, but the types of wood also show clear differences in pyrolysis behaviour, among themselves. These values are also related to the chemical composition of the feedstock and the mechanical stability of the pyrolysis coke in order to be able to draw conclusions about the necessary pyrolysis conditions in the gasification plant.

Acknowledgement: The financial support by the Austrian Federal Ministry for Digital and Economic Affairs and the National Foundation for Research, Technology and Development, the Christian Doppler Research Association as well as the participating companies is gratefully acknowledged.

Do recovered wood streams always fulfill criteria for combustion?

Martin Weigl-Kuska
Holzforschung Austria
Franz-Grill-Straße 7, 1030, Vienna, Austria
m.weigl-kuska@holzforschung.at
www.holzforschung.at

Co-Author: Christina Fürhapper

In theory traditional wood use is a circular process due to fixation and release of CO_2 throughout its entire product lifetime starting in the forest, ending with incineration and re-entering the circle in future forests. In practice, wood use is much more a linear process, whereby cascade use at least provides more application options originating from a single resource harvested at a time. Such a cascade use of wood typically ends with combustion, however, mainly driven by fatalistic thinking – in other words ignoring that even for energetic use, wood quality criteria are essential.
Re:use of recovered wood is not new, but currently gains further interest; e.g. driven by the EU green deal. By now, main portions of recovered wood go either towards the particle board industry or end up in industrial or municipally HPs or CHPs. The differentiation among these material streams is driven by material quality and market situation (e.g. price, availability, contracts). The current development towards a real circular application of wood in all dimensions, especially with focus on solid wood and adhesive bonded wood resources will lead to changed market conditions. Hence high-quality material will be kept in the material circle. Quality criteria do not only cover the primary functionality (e.g. static properties), but also soundness. On the other hand, contaminated wood (e.g. from wood preservatives, surface treatments, glue, burning) will be consequently rejected from such circles. This will lead to higher portions of such quality assortments of recovered wood materials potentially available for combustion and a rising risk regarding the exceedance of existing threshold values.
Different legal documents apply as it comes to application of recovered wood. Requirements for the classification of recovered wood streams vary between European states, such as it is the case in Austria and Germany. The Austrian Recyclingholzverordnung requires the sorting of recovered wood streams and defines materials, that definitely have to go for incineration (e.g. windows, doors, preservative treated wood, fibreboards, contaminated wood, wood in combination with further residues, burned wood), and excludes others from any re:use at all (railway sleepers, pols, workshop floorings, storage bins for munitions). In this respect, it is questionable if these categories cover real material quality variations effectively, and if a simple sorting process can guarantee flawless processing of all recovered wood streams or suits just the ones meant for high value applications.
This study presents results from chemical analysis of recovered wood including a wide range of original applications. The analysed material originated primarily from wooden windows and historical wood applications such as floorings, non-weathered construction elements, or facades. Overall, the investigations focussed on the material state at its end of life (EoL), hence covering all originally applied ingredients, including some that might be restricted by now and that don´t represent the current state of the art for construction products. The utilisation history of recovered wood components is often unknown. Even if initial information about the products is available, later surface treatments are commonly not recorded. This information gap can only be closed by detailed (chemical) analyses at the EoL.
Results show typical contaminations, both relevant for solid material re:use as well as for combustion. Aged windows e.g. often exceed heavy metal thresholds, problematic substances mostly originate from surface coatings. Frequent critical compounds in connection with recovered construction wood include heavy metals and halogens. In this case the source can most likely be found in a treatment with biocidal preservative products or the application of fire retardants. Even for state-of-the-art building products, material aging accompanied with release of such substances is known. However, contents of such substances at EoL, both for historical and recent buildings products made of wood, are unknown. They can´t be assumed for material entering further life cycles or waste streams entering the energetic pathways.
The study demonstrates the potential of a regular industrial quality control and the necessity of analytical methods beyond the normative requirements. The results imply that quality control of recovered wood, independent from its intended use, should be strict, in order not to undermine environmentally driven processes (e.g. circularity) by environmental risks.
Results are based on Bau-Cycle (ACR SP-2020-01), FFG-Nr. 878049, and FFG-Nr. 38863385.

Quality monitoring of practical wood chips samples

Josef Rathbauer
HBLFA Francisco Josephinum - BLT Wieselburg
Rottenhauser Straße 1
3250 Wieselburg, Austria
josef.rathbauer@josephinum.at
https://www.josephinum.at/forschung-und-pruefung/biomasse.html

Co-Authors: Kurt Krammer, Lukas Sulzbacher, Rudolf Zeller

In the last years several projects have been carried out where the influence of the woody raw material, the species of trees, the chipping process, the storage conditions etc. on the fuel quality and the respective parameters have been analysed. A still open question was the quality of the solid biofuels in the storages just before the combustion.

It is generally acknowledged that the qualitative properties of the biogenic solid fuel have a strong influence on the combustion behaviour and the emissions of biomass heating appliances, especially in small scale furnaces with no secondary flue gas treatment. In international standards (EN ISO 17225 series) the relevant parameters and limits for these parameters are defined.

In a three years lasting monitoring project 259 wood chip samples were taken, processed, analyzed and classified. The results were compared with the limits set in the respective solid biofuel standards. The main test results were communicated to the operators of the plant via Email.

The water and ash contents were in a very low range in the majority of the samples. This results in unexpectedly high specific energy contents (e.g. average bulk density multiplied by average calorific value >1000 kWh/loose m³). This shows that the operators attach importance to the fuel quality used in their furnaces and are actively striving for it.

The results of the bulk density (mean value 260 kg/m³) indicate an evident proportion of hardwood in the samples. The grain size distribution (165 samples P31S) reflects practice. Due to the chipping technology used (drum chipper with appropriate sieve), the sample results are homogeneous.

As can be expected with wood chips, the results of the determination of the ash melting behavior are mostly in the harmless range. A few outliers may be due to secondary impurities.

The contents of the major and minor elements are similar to relevant literature values (e.g. www.phyllis.nl).

The installation year of the furnaces, in which the wood chip samples were taken, was between 1982 and 2019. On average, 630 loose cubic meters of wood chips per heating season per system are used to generate heat. The smallest annual consumption was 30, the largest at 6,500 loose cubic meters of wood chips.

The bark beetle calamities in spruce and the ash dieback have contributed to the fact that trunk wood that can hardly be sold was processed into wood chips. This may be a major reason for the high quality of the fuel samples examined.

Accurate determination of the application critical parameter Cr(VI) in Biomass Ash

Michael Ecker-Eckhofen

BEST - Bioenergy and Sustainable Technologies GmbH

Inffeldgasse 21b, 8010 Graz, Austria

michael.ecker-eckhofen@edu.uni-graz.at

https://best-research.eu/

Co-Authors: Norbert Kienzl, Doris Kuehnelt, Stefan Retschitzegger, Christoph Rosenberger

The energetic use of lignocellulosic biomass in heating plants produces over 250.000 tons per year of biomass ash alone in Austria. Meaningful and cost-efficient utilization options for this resource stream are necessary. Ashes from biomass combustion increase soil pH and contain valuable nutrients, such as potassium, magnesium, and phosphorous, and are, therefore, used as fertilizers in the agricultural and forestry sectors. For this use, however, ashes need to comply with certain limits for heavy metals. Since the introduction of a new limit for Cr(VI) in 2017, a significant number of ashes cannot be used anymore and has to be costly disposed of. Additional discussions on the accuracy of lab results initiated a study in close cooperation with the Austrian Biomass Association and heating plant operators to investigate and compare the influence of sample preparation and measurement techniques on the determined Cr(VI) concentrations in biomass ash. Furthermore, a country-wide screening of the current status of heavy metal contents in ashes from Austrian heating plants, with a focus on Cr(VI), was performed.

For the determination of Cr(VI) in ashes from biomass combustion standardized methods (EN 16318 A and B) are recommended. These methods are based on procedures for fertilizer or landfill waste analysis and allow different extraction methods as well as a variety of different detection techniques. Aqueous and hot alkaline extraction in combination with three independent detection techniques - photometry, ICP-AES, and HPLC-ICP-QQQ-MS - were investigated for their influence on the determined Cr(VI) concentrations in biomass ash. Based on the results of this systematic investigation, 84 ashes from more than fifty combustion sites in Austria and their respective biomass-feedstocks were subsequently analyzed for their total element and Cr(VI) content.

All three independent detection techniques generated comparable Cr(VI) contents, were validated with a certified reference material, and are, hence, suited for the determination of Cr(VI) in ashes from biomass combustion. Our findings showed, however, that the applied extraction procedure has a significant impact on the determined Cr(VI) content. Due to longer extraction times and higher temperatures, alkaline hot extraction yielded significantly higher results than aqueous extraction. On the other hand, the latter better simulates eventual leaching of heavy metals into the environment by rain, and was, therefore, chosen for the screening of ashes from Austrian heating plants. The results of the screening study clearly showed that Cr(VI) is the predominant parameter inhibiting legal decentral soil application of biomass ash in Austria and the urgent need for further investigations into limiting this species in ash.

Towards a more accurate and fast determination of parameters impacting the calorific value of solid biofuels

Anne Mette Frey
Danish Technological Institute
Kongsvang Alle 29, DK-8000 Aarhus, Denmark
amfr@teknologisk.dk
www.teknologisk.dk

Helena Strauss, Henrik Kjeldsen, Jan Nielsen, Lars Schwarzer, Anne Mette Frey, Bayan Tallawi, Eric Georgin* (* Centre Technique des Industries Aérauliques et Thermiques)*

Aim:
The aim of this study, carried out as a part of the BIOFMET project, is to optimize energy production based on solid biofuels through more accurate and faster on-line determination of parameters impacting the calorific value (moisture, impurities, ash-content) and the combustion. This is found to be a major challenge of today e.g. in connection to wood chips being a relatively inhomogeneous material, where knowing water content and calorific value is of key importance for fair price as well as an optimal combustion.
The objectives of the project:

- To develop traceable online measurements for water content in solid biofuels
- To develop improved methods for the sampling of biofuels
- To develop validated methods for the at-line measurement of ash content.

Results:
In this paper the project and some of the already obtained successful results will be presented:

- Two new moisture transfer standards are developed for the calibration of on-line equipment. They are non-destructive, non-invasive and fast and will be superior to the very material-specific instruments currently available on the market.
- Traceability is ensured by new calibration methods based on reference methods or Certified Reference Materials developed during the project.
- A representative sampling strategy aimed at reducing the uncertainty of sampling of solid biofuels from trucks. Robots are developed, implemented and demonstrated.
- Advanced data-science techniques such as machine learning and deep learning is applied to reduce the uncertainty of the on-line measurements.

Freitag
20
Jänner

11:00–12:30 Uhr

Parallelblock 13

Flexible Bioenergie und biomasse-basierte hybride Energiesysteme

Friday
20
January

11:00 am–12:30 pm

Parallel Session 13

Flexible bioenergy and biomass-based hybrid energy systems

Project DigitalFire: Increasing the fuel flexibility of biomass firing systems through online sensors

Jürgen Oischinger M.Sc., Martin Meiller M.Eng., Dr.-Ing. Robert Daschner,
Fraunhofer UMSICHT, Fraunhofer Institute for Environmental Safety, and Energy Technology,
An der Maxhütte 1, 92237 Sulzbach-Rosenberg, Germany
juergen.oischinger@umsicht.fraunhofer.de *martin.meiller@umsicht.fraunhofer.de*
robert.daschner@umsicht.fraunhofer.de

In Germany there are numerous biomass boiler systems and biomass cogeneration plants. In order to operate economically, these plants must increasingly be able to process fuels of lower quality, including biogenic residues. Most systems are basically capable of doing this and some also have appropriate programs for the respective input materials. For fuels such as forest residues or bio- genic residues, however, the parameters usually have to be set manually. This is time-consuming and requires a lot of experience.

In the end, it is a question of adjusting the combustion control in such a way that a stable com- bustion process with high combustion quality of solids and gas phase and thus a high degree of efficiency is achieved. Incorrect firing adjustments lead to higher emissions and, in the worst case, to higher wear with subsequent maintenance and downtime. This is where digital technology comes into play: If advances in control and regulation technology make it possible to run lower fuel qualities with the same output, there will quickly be an economic benefit.

With a focus on the range from 100 kW to 20 MW thermal output, biomass plants are to be optimized in the following areas:

- Increase in fuel flexibility,
- Increasing availability and reducing downtime,
- Reducing emissions and
- Increase in efficiency.

In order to achieve the planned goals, a large amount of information about the input material used was obtained by means of image recognition, evaluation of acoustic signals and moisture sensors as well as drying of a partial flow of the fuel. The various components were integrated into the feeding system of a grate furnace (thermal output: 440 kW). The data obtained, e.g. regarding fuel composition and quality, is evaluated using machine learning methods or artificial neural networks. The information from the various modules is then made available to the user online. A recommendation is given when the appropriate fuel arrives at the selected setting in the furnace and which parameters the user should adjust. The systems were first trained with different fuels (wood chips from logs and forest residues, pellets and sawdust) and then tested during combustion experiments with selected fuels. During the lecture, the various modules as well as the results from the combustion tests will be presented.

Increasing the flexibility of a fixed-bed biomass gasifier through model-based control strategies: method and practical verification

Clemens Hollenstein
BEST – Bioenergy and Sustainable Technologies GmbH,
Inffeldgasse 21b, 8010 Graz
clemens.hollenstein@best-research.eu
https://www.best-research.eu/

Co-Authors: Christopher Zemann, Stefan Martini, Markus Gölles, Wolfgang Felsberger, Martin Horn

Future hybrid energy systems require flexible technologies for compensating the volatile nature of most renewable energies. As such, fixed-bed biomass gasifiers are especially relevant as they allow a flexible production of heat, electricity and in a broader sense bio-based products (e.g. biochar). Thus, flexible fixed-bed biomass gasifiers will continuously become more relevant for a sustainable and highly flexible energy and resource system (bioeconomy).

However, due to their current economic dependency on specific feed in tariffs for the produced electricity, they are almost always operated at nominal load, to maximize the electricity production. Thus, their potential for flexibility has not been revealed up to now. Consequently, the currently applied control strategies are typically designed with the focus on steady-state operation. Any operation differing from nominal load typically requires manual interventions of the plant operators to avoid lower efficiencies or operational difficulties. Thus, currently applied control strategies do not allow a fully-automatic and flexible operation of the gasifiers.

To unleash the full potential of the gasifiers' flexibility, new and more advanced control strategies able to handle varying operating conditions automatically are required. For this reason, this contribution aims for the development of a model-based control strategy, since it allows to explicitly consider all the correlations between the different process variables, and an efficient adaptation of the control strategy to different plants. The development was carried out on the basis of a representative industrial small-scale fixed-bed biomass gasifier operated as combined heat and power plant (CHP) with a nominal capacity of 300 kW_{th} and 150 kW_{el}. In this contribution we present the developed method as well as the practical verification of the model-based controller for the industrial small-scale fixed-bed biomass gasification plant.

The practical verification revealed a significant potential for flexibility increase by the new model-based control strategy in comparison to state-of-the-art control strategies. For example, the new controller performs a step-wise load change from 150 kW_{el} to 100 kW_{el} (-33%) within less than 2 min without affecting the gasification performance. The new control leads to a much more homogeneous gasification, in particular during partial load operation, and reduces the fluctuation margin of relevant process parameters to less than 1%. This controlled stabilization and homogenization of the gasification at different operating conditions is also a prerequisite for further future flexibilization measures, e.g. the extension of the feedstock variety (fuel flexibility) or increasing product flexibility.

Due to the modular and model-based design, the new control strategy can also be implemented on other fixed-bed gasifiers of the same type without requiring any structural modifications, by solely adjusting the model parameters appropriately. Furthermore, the new control strategy makes only use of sensors and actuators typically already available in state-of-the-art fixed-bed gasification systems. In conclusion, the model-based control strategy to be presented states a very important contribution towards flexible fixed-bed biomass gasification systems.

Elements and solutions for the flexibilization of biomass-based district heating networks

Joachim Kelz
AEE - Institute for Sustainable Technologies
Feldgasse 19, 8200 Gleisdorf, Austria
j.kelz@aee.at
https://www.aee-intec.at

Co-Author: Ingo Leusbrock

Complete decarbonization of the heating sector is currently a major challenge. Biomass-based district heating networks and systems play a central role in sustainable heat supply covering around 2,400 systems in operation in Austria. Ongoing technical innovations, digitalization as well as systemic changes in heat supply offer further potential to expand and strengthen this market position. In order to increase efficiency as well as flexibility and meet future challenges, sustainable heat and waste heat sources as well as infrastructures must be integrated and different energy sectors must be coupled. Currently, district heating networks are mainly supplied centrally with a few generation plants, the use of local resources requires an increased decentralization of heat generation. Due to the larger number of generation plants on the one hand and due to the limited temporal availability on the other hand (fluctuations), the degree of complexity and the need for flexibility options increases. Solutions and elements such as heat storage (centralized, decentralized), coupling of energy sectors and infrastructures, predictive control concepts and the integration of users and stakeholders will be of great importance in future. In parallel, highly integrated planning, implementation and operational management processes will gain great importance, e.g., new facets of spatial energy planning, life cycle analysis, stakeholder integration as well as data analysis and monitoring for efficient operation.

ThermaFLEX[1] explicitly had the ambitions to tackle the challenges and to demonstrate the developed solutions in 11 demonstration cases, so-called demonstrators. A methodology with three different pillars was applied including a) technical measures, b) systemic approaches and c) non-technical measures. A wide range of different measures, heat sources and flexibility elements were developed and the entire process (from problem identification, concept development, detailed planning and implementation, data monitoring and optimization, system evaluations to the development of best practices and roll-out scenarios) was accompanied. The demonstrators differ largely in scale, type of challenges addressed and solutions demonstrated. In the following, we introduce the biomass-based demonstrators, highlight their innovative elements and give a brief overview:

- Gleisdorf: The central element was the coupling of district heating with the municipal waste-water treatment plant providing thermal energy from the wastewater and biogas. In addition, an innovative control system, the "virtual heating plant", was implemented.
- Mürzzuschlag: Integration of a large solar thermal plant (about 5,000 m²) in combination with storage (180m³) was realized. Solar yield expansion by another 2,000 m² and additional storage capacity is planned for early 2023.
- Leibnitz: 100% renewable heat and complete natural gas phase-out by using fluctuating waste heat and bidirectional interconnection of the existing district heating networks. Optimization through high-level energy management system for both, district heating network and heat generation operation.
- Saalfelden: Development of a holistic multi-stage modernization concept. Stage 1 (technical modernization) was finalized in 2020 and stage 2 (integration of a heat pump to further increase efficiency) is planned for 2023.

In conclusion, implementations were already realized within the linked demonstrators and showcase the great potential of the developed elements and solutions for the decarbonized heat infrastructure in different Austrian biomass-based district heating networks.

[1] This project is supported with the funds from the Climate and Energy Fund and implemented in the framework of the RTI-initiative “Flagship region Energy”.

Predictive control of biomass and biogas-based CHPs at the intersection between the electricity grid and heating networks – Improving electricity market participation through optimization and demand side management

Daniel Muschick
BEST – Bioenergy and Sustainable Technologies GmbH
Inffeldgasse 21b, 8010 Graz, Austria
daniel.muschick@best-research.eu
https://www.best-research.eu/

Co-Authors: Valentin Kaisermayer, Hermann Edtmayer, Richard Heimrath, Thomas Mach, Markus Gölles

As the transition towards a carbon neutral energy system progresses, the integration of renewables delivering fluctuating energy (solar thermal, photovoltaics, wind power) increasingly requires other forms of carbon neutral energy sources to either provide the base load or to provide flexibility to stabilize the grid or network. Biomass-based technologies (biomass steam / thermal oil boilers, biomass gasification and biogas CHPs) are uniquely suited to fill this gap since their output can be modulated, they can operate all year round and, at least in countries with established sustainable forestry such as Austria, they can be regarded as sustainable and carbon neutral.

By participating in the electricity markets, either directly or as members of a pooling solution, they can play an active role in the stabilization of the grid. Even the participation in balancing energy markets (at least at the secondary and tertiary level) is theoretically possible – wood gasifiers, e.g., can be made fast enough with advanced control engineering[1].

However, as with all caloric power plants, the CHPs require a sufficient amount of heat demand matching the electricity demand in order to be truly efficient. Ideally, the plants are connected to heating networks which provide some degree of flexibility, possibly through the use of heat storage. Using forecasts of the heat demand and a model of the storage capabilities then allows to optimize the operating schedule of the plant, thus being able to profit from high electricity market prices and to avoid selling at low prices. In the absence of thermal storage, or if it is not big enough, an active modulation of the demand profile by demand side management (DSM) measures can provide some flexibility in the market participation.

In our presentation, we will present the idea and first results from the project BioControl4Power, where we provide an overview of the possibilities of electricity market participation of biomass-based CHP technologies and how, based on fluctuations in energy prices, operators can benefit from employing an optimized operating strategy that actively uses the flexibilities offered by both thermal storage and DSM measures in the heating network. The operating strategy will be the result of a model-predictive controller (MPC) currently under development which orchestrates not only the different producers of power and heat and generates plans of operation that are communicated to the energy trader, but also actively integrates the DSM measures and includes this flexibility potential in its optimization. The MPC is part of a framework that is modular and can easily be adapted to different energy hub configurations.

Based on simulation studies of two demonstrators covering different biomass-based CHP technologies and equipped with the necessary ICT infrastructure to obtain online measurements and perform validating experiments, the networks of Reidling and Melk, different DSM measures in combination with model-predictive control will be evaluated. The results will showcase the load shifting potential in typical networks and the associated economic benefit from optimized market participation. Based on the simulation results the possibilities for electricity market participation of biomass-based heating networks with CHP technologies, and in particular the technical and economic boundary conditions will be evaluated.

[1] Hollenstein, C., Zemann, C., Martini, S., Gölles, M. Felsberger, Horn, M.: Increased flexibility of a fixed-bed biomass gasifier through advanced control. Proceedings of the 30th European Biomass Conference and Exhibition, 2022

11:00–15:00 Uhr

Workshop

Biokohle – Der Wertstoff im Werkstoff

11:00 am–03:00 pm

Workshop

Biochar – a valuable additive for advanced material

Electrically Conductive Biocomposites Based on PHBV and Wood-Derived Carbon Fillers

Christoph Unterweger
Wood K plus – Kompetenzzentrum Holz GmbH
Altenberger Strasse 69, 4040 Linz, Austria
c.unterweger@wood-kplus.at
https://wood-kplus.at/en

Co-Autoren: Matija Ranzinger, Jiri Duchoslav, Francesco Piana, Igor Pasti, Franz Zeppetzauer, Stefan Breitenbach, David Stifter, Christian Fürst

Bio-based carbons were used as fillers in poly(3-hydroxybutyrate-co-3-hydroxyvalerate) (PHBV). The mechanical and electrical properties of these 100% bio-composites were analyzed. Bio-carbons were prepared from wood dust and cellulose fibers using carbonization temperatures ranging 900 – 2300 °C. XRD revealed significant improvements of the graphitic structure with increasing temperatures for both precursors, with slightly higher ordering in wood dust based carbons. An increase of the carbon content with continuous removal of other elements was observed with increasing temperature. The carbonized cellulose fibers showed an accumulation of Na and O on the fiber surface at a carbonization temperature of 1500 °C. Significant degradation of PHBV was observed when mixed with this specific filler, which can, most probably, be attributed to this exceptional surface chemistry. With any other fillers, preparation of injection-molded PHBV composites was possible without any difficulties. Small improvements compared to the mechanical performance of neat PHBV were observed, with carbonized fibers being slightly superior to the wood dust analogues. The fiber-based samples slightly outperformed the corresponding wood dust samples in terms of modulus, HDT and impact strength. No influence of the carbonization temperature on the mechanical performance was observed, but the higher filler content led to increased modulus and HDT as well as decreased elongation at break. Generally, only slight differences were found, which, we assume, is connected to the low L/D, which was only approximately 12 for the fibers samples. Even in the electrical conductivity, no impact of the carbonization temperature could be observed, despite significant differences in the graphitic structure of the used carbon fillers. The filler content or the L/D were too low to reach a conducting network at a filler content of 10 vol%. In the range of 15 – 20 vol% carbonized fibers, the percolation threshold could be reached, resulting in electrical conductivity of 0.7 S/cm. For comparison, polypropylene composites using cellulose fibers carbonized at 2000 °C were prepared, reaching a higher L/D of 19 and achieving percolation already in the range of 5 – 10 vol.% CF. However, compared to composites with commercial CF, higher electrical conductivity was achieved when using carbonized cellulose fibers. This could be attributed to the different structures of the used CF. While the commercial PAN-based CF are completely straight, the cellulose-based CF are usually curved and tend to interlock quite easily. Therefore, it could be expected that the formation of a tighter conducting network might occur.
Overall, the results show great potential for composites with biomass-derived carbons in electrical applications. Even though man-made cellulose fibers have been used in our study, we assume that the results should transfer well to other materials, including natural fibers or textile waste.

Freitag
20
Jänner

13:30–15:00 Uhr

Workshop

Digitale Technologien in der Land- und Forstwirtschaft – Aktueller Stand und Ausblick

Friday
20
January

01:30 pm–03:00 pm

Workshop

Digital technologies in agriculture and forestry – current status and outlook

Was leisten moderne Farmmanagement- und Informationssysteme?

Reinhard Streimelweger
Josephinum Research
Rottenhauser Straße 1, 3250 Wieselburg, Austria
r.streimelweger@josephinum.at
www.josephinum.at

Landwirtschaftliche Betriebe sind im Zuge der fortschreitenden technologischen, ökologischen, ökonomischen sowie rechtlichen Entwicklungen verstärkt mit der Erfassung von Daten bei der Bewirtschaftung sowie deren Dokumentation am Betrieb konfrontiert. Ebenso gibt es die Tendenz der steigenden Verbrauchererwartungen an die produzierten Lebensmittel, wie etwa in puncto Nachhaltigkeit. Um den daraus resultierenden Herausforderungen besser entsprechen sowie den Anforderungen der LandwirtInnen bei der Bewirtschaftung bessere Entscheidungsgrundlagen bieten zu können, ist der Einsatz eines digitalen Werkzeuges für das Management durch den Einsatz eines FMIS, also einem Farmmanagement- und Informationssystem, denkbar. Welchen Nutzen ein solches FMIS für den Anwender haben kann, hängt unter anderem vom Anwender selbst, der Nutzerfreundlichkeit, der Kompatibilität, den rechtlichen Rahmenbedingungen und den verschiedenen Funktionalitäten eines FMIS ab.

Der Einsatz eines FMIS ermöglicht die Optimierung der Bewirtschaftung, z.B. durch eine bessere Dokumentation von Maßnahmen und die Verknüpfung von Daten auf und um den Betrieb. Ein FMIS kann den Einsatz von Precision-Farming-Technologien unterstützen, insbesondere bei der Fahrspurplanung oder der standortbezogenen Bewirtschaftung. Die Vorteile des Einsatzes eines FMIS können vielfältig sein, wobei neben der Einsparung von Betriebsmitteln generell die Arbeitsentlastung bei der Dokumentation hervorzuheben ist. Es gibt viele Gründe, warum potenzielle Nutzer FMIS nicht einsetzen. Der Nutzen liegt jedoch in den Funktionen und ganzheitlich in den bereitgestellten Entscheidungsgrundlagen. Der Vorteil liegt in der Optimierung der Bewirtschaftung auf der Managementebene und kann bei richtiger Anwendung zu ökologischen und ökonomischen Vorteilen führen. Der Einstieg kann zeitaufwendig sein, was aber nicht nur vom gewählten System, sondern auch vom Nutzertyp abhängt.

Um den Nutzen eines FMIS für den Anwender darstellen zu können, kann bei einem Systemvergleich nach Kriterien wie Funktionen, Anbieterinformationen (z.B. Service, etc.), Allgemeine Systeminformationen (z.B. Updates, Zugriffsmöglichkeiten, etc.) aber auch Bedienerfreundlichkeit, Datensicherheit und Datenhoheit vorgegangen werden. Zentral für den Nutzen von FMIS sind jedoch die Funktionen die ein solches umfassen kann. Ausgehend von der digitalen Ackerschlagkartei, wo sämtliche Maßnahmen auf Schlagebene aufgezeichnet werden können, stellt ein FMIS das digitale Werkzeug für das Datenmanagement bereit, um bei der Betriebsführung und Bewirtschaftung zu unterstützen. Der Trend im Speziellen geht in Richtung teilflächenspezifischer Bewirtschaftung in Aussaat, Düngung und Pflanzenschutz. Hier können Planung und Überprüfung von Maßnahmen im Feld besser unterstützt werden.

Field management and logistics: How to benefit from satellite data and digital tools

Johann Prankl, Andreas Prankl, Peter Riegler-Nurscher[1]
Farmdok GmbH
Krügling 7, 3250 Wieselburg, Austria
office@farmdok.com
www.farmdok.com

Minimising empty runs, waiting times and the effort required for coordination, which is usually done by telephone, is a challenge, especially for agricultural service providers, contractors and harvesting chains with several vehicles. Currently, the time and meeting point contractors and farmers are mostly coordinated by telephone. The contractor is often guided to the exact location of the field directly by the farmer or via telephone. After the time-consuming coordination, the yield and consequently the working hours for processing the field can only be estimated at the field. Even if the farmer has previously indicated the size of the field, the time required for the work only becomes visible on site. Planning of the schedule for a day can only be a best guess and coordinated with the farmer shortly before the actual arrival.
With modern technologies, the workload can be estimated in advance, planning optimised and communication between farmer and contractor supported. In FMIS Farmdok, this process is supported by the following functions and modules:

- Creating a field with the Farmdok One-Click-Wonder (also available mobile on the smartphone). The field position is marked on the map with one click and Farmdok automatically determines the geo-contour and the size of the field from satellite data or contours from the previous year.
- Direct import from eAMA: Many contractors already offer complete packages for their customers, e.g. crop protection in a package including records. The farmer provides all field data in advance. In Farmdok, field data from the grant application can be loaded directly into Farmdok via an API from eAMA.
- File import: If the field data are already available in the form of a Shape, XML or KML file, they can be easily uploaded into Farmdok.
- Data shared directly from the customer farm. If the farmer is a Farmdok user, he can be invited by a Farmdok Business Partner/ contractor to send the field locations digitally. The contractor receives the field information without having to create it himself.
- "Live sharing" of own position. Each driver sees the fields to be processed, can share his location and sees as well where the other drivers are. Based on the track of the lead vehicle, it is recognised what has already been worked on and what has to be done.

In order to optimise logistics and work planning, the amount of work and thus the yield or biomass in the field must be estimated. In a joint project with Josephinum Research, an AI model was developed with which the site-specific biomass can be predicted from satellite data. One of the biggest challenges in processing satellite data in the visual and near-infrared range are atmospheric disturbances, such as clouds. Currently, approaches such as linear interpolation of data are mostly used to estimate the status of vegetation in cloudy conditions. Our new method uses Deep Learning with an artificial neural network (ANN) to predict vegetation indices NDVI, LAI, NDWI, CIre from Sentinel-2 and weather data. The model estimates the growth and status of the crops and the biomass in kg/m² under cloudy conditions, taking into account the weather.
Initial tests have shown that the prediction of the Leaf Area Index (LAI) achieves a Pearson correlation of 0.943. A Pearson correlation of 0.72 is achieved when estimating the biomass of grassland and forage.
Digital tools revolutionise many existing ways of working and offer a better way than previously possible. The digital exchange of information enables efficient teamwork. Satellite and weather data can be used to estimate biomass, optimising logistics and reducing manual work. That is, how our project contributes to optimizing management and logistics with artificial intelligence, satellite data and digital tools.

1 Josephinum Research, Wieselburg

Digitale Tools für die standortangepasste Düngung

Ing. Lukas Handl
Josephinum Research
Rottenhauser Straße 1,
3250 Wieselburg
jr@josephinum.at
https://www.josephinum.at/

In the course of several research projects, it was possible to achieve that every farmer in Austria can implement site-specific management on his or her farm without having to rely on costly and technically complex technology. Through the use of satellite imagery in agriculture, fertilisation can be carried out in a more ecological and resource-saving way, which not only helps the environment but also the farm itself in terms of management. Both software and guides for assistance were generated and evaluated together with pilot farms in order to achieve the greatest possible practicality.
Online tools such as “TerraZo” offer farmers the possibility to easily generate fertiliser maps based on satellite data. Once a personal account has been created, a platform is available on which the farmer's own fields can be created and saved for further use. With just a few simple steps, ready-made fertilisation maps are created and fertilisation recommendations are suggested based on suitable models for the respective location and crop. These models are continuously expanded and evaluated through numerous field trials in the most important arable farming areas in Austria. New findings from science and research can thus be made directly available to farmers.
In order not to be dependent on new and expensive technology when using these fertilisation maps, useful and free smartphone apps such as “GIS-ELA” are available. These tools visualise the previously generated maps and thus help with orientation and navigation in the field. The farmer then changes the application rate himself according to the available possibilities.
Within the framework of the Farm-to-Fork strategy, the goal of reducing the need for fertiliser by 20% has been set. Based on field trials by Josephinum Research over several years, a saving in fertiliser requirements of about 12% was achieved for winter wheat. By further optimising the models, the goal of the European Union can be achieved in the future without having to accept a reduction in yield and quality.
In addition, site-specific fertilisation makes it possible to identify sub-areas at risk of leaching and to supply them specifically according to their nutrient requirements in order to keep nutrient surpluses and the resulting environmental pollution as low as possible.

Artificial Intelligence (AI) in Agriculture: Challenges, Benefits and Use Cases

Peter Riegler-Nurscher
Josephinum Research
Rottenhauser Straße 1, 3250 Wieselburg, Austria
p.riegler-nurscher@josephinum.at

Artificial Intelligence (AI) has gained popularity due to its high potential in different areas. Also in agriculture, especially in arable farming, AI offers many use cases and potentials. These include precision farming, crop monitoring and yield prediction, robotics, or improving supply chain management. From an environmental standpoint, the European green deal and the common agricultural policy (CAP) are aiming for pesticide reduction, halting soil degradation and biodiversity. AI can play a key role in achieving these goals.
Precision farming involves using Machine Learning, a form of AI, and other technologies to collect data on soil conditions, weather patterns, and other factors to optimize crop production and reduce the use of resources such as water and pesticides. AI can also be used to monitor crops alerting farmers to potential issues such as disease or pests. In arable robotics, AI is applied for process monitoring and environmental sensing. In the supply chain, AI can be used to track the movement of goods and predict demand, helping to ensure that the right amount of food is produced and distributed to meet consumer needs.
Computer vision is the main area of AI used in agriculture, as the farmer's work is also based a lot on visual perception. The source data for these applications usually comes directly from the ground (smartphones, cameras mounted on robot or conventional farming equipment), unmanned areal vehicles (UAV) or from satellites. Data collected on the ground not only include images also other sensor data like multispectral sensors, LIDAR or radar sensors and various soil sensors can be integrated into AI models. The area of multispectral sensing has gained popularity especially in UAVs and satellites. Thereby, models are created not primarily on the basis of geometric but radiometric information.
Of the extensive use cases, some have already more or less arrived in practice, such as weed detection or yield prediction. Other applications such as vision based plant pest and disease detection are still being researched until they can be applied on a large scale.
There are several challenges that AI faces when it comes to agriculture. One of the main challenges is the lack of high-quality data. Farming is a complex and dynamic industry, and collecting accurate and reliable data is usually difficult. Additionally, there is often a lack of standardized data formats, which can make it difficult to integrate different data sources. In many applications, especially in robotics, integration into existing processes has not yet been optimized. However, these optimizations are necessary in order to be able to use them economically.
Overall, the use of AI in agriculture has the potential to increase efficiency, reduce waste, and improve the sustainability of the food system.

Freitag
20
Jänner

13:30–15:00 Uhr

Parallelblock 14

Herstellung, Veredelung und Nutzung von Biokohle- und Biomasseaschen

Friday
20
January

01:30 pm-03:00 pm

Parallel Session 14

Production, upgrading and use of green carbon and biomass ashes

Potential of bottom ashes from non-woody biomass combustion as sustainable supplementary cementitious materials

Hossein Beidaghy Dizaji[1], Dripti Kulshresth[1], Thomas Zeng[1], Steffen Overmann[2], Anya Vollpracht[2]*
[1] DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Torgauer Straße 116, 04347 Leipzig, Germany
[2] Institute of Building Materials Research, RWTH Aachen University, Schinkelstraße 3, 52062, Aachen, Germany
** Corresponding author: hossein.beidaghy@dbfz.de, phone: +49 (0)341 2434-539*

Concrete is the most produced material in the world while being the second most consumed substance after water on earth, and its production keeps increasing annually [1,2]. The worlds cement production capacity is currently higher than 4200 Mt per year, and 0.5 t of cement is utilized on average each year for every single person on the planet [2]. Production of 1 t cement emits approximately 0.5-0.6 tCO_2, and it consumes 2.8 GJ of energy [2]. Portland cement is the most common type of cement in general use around the world as a basic ingredient of concrete or mortar which can be used for all kinds of constructions as it is compatible with practically all conventional construction materials. Portland cement produced out of a mixture of 80 wt.% limestone, and 20 wt.% clay minerals [3]. During the calcination process, where calcite ($CaCO_3$) is calcined by releasing carbon dioxide, 50 % of the CO_2 emission is emitted while 40 % of the CO_2 emission is related to the high temperatures (about 1450 °C) of the process. Finally, 10 % of CO_2 emission are caused by quarrying and transportation of the products [4]. In order to reduce the CO_2 emissions in this process, the clinker can be replaced by fly ash, calcined clays, slag, biomass ashes, and other reactive components [5]. The previously investigated ash fractions were typically fly ashes generally coming from coal combustion plants. However, since their characteristics (e.g. high K and Cl and C content) might be not suitable as well as they mark the lower share of the ash fractions, bottom ashes might be better suitable. Also, the International Energy Agency predicted a gradual reduction of clinker production over the next few years, which has a significant impact on reduction of global CO_2 emissions [2]. In this respect, bottom ashes from the combustion of pelletized agricultural residues (rice husk, spelt husk and washed foliage) were screened to be used as supplementary cementitious materials in both lab-scale (i.e., muffle oven operated at 700, 800 and 900 °C) and bench-scale (i.e., commercially available boiler with a nominal heat capacity of 50 kW). The produced ash samples from the solid biofuels were characterized in terms of chemical composition, carbon content, slag formation tendency, pH value, porosity and reactivity. First results from the material screening showed that spelt husk and foliage ashes have good performance as compared to rice husk ash or different siliceous and calcareous fly ashes (SFA_R, SFA_I, SFA_E, CFA_P, and CFA_S samples in Fig. 1) from coal combustion studied in literature [6]. Further analysis of the selected samples (Fig. 1) proved that pelleting spelt husk with only 1 wt.% d.b. of kaolinite can stabilize the ash reactivity with respect to the investigated temperature range. In terms of homogeneous product quality, this is also relevant for the ash production in real-scale boilers with fluctuating combustion temperatures. Thermodynamic equilibrium calculations presented in Fig. 2(a-c) also confirmed different ash transformation chemistry in the selected ashes. Combustion tests on bench-scale are currently underway to confirm applicability of the bottom ashes as sustainable supplementary cementitious materials.

References

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Influence of thermochemical conversion on the pelletability and pellet quality of biomass

DI Niklas Illich
BEA Institut für Bioenergie GmbH
Avedikstraße 21, 1150 Wien
niklas.illich@bioenergy.co.at
www.bioenergy.co.at

Support by DI Dr. Martin Englisch and DI Dr. Prof. Christoph Pfeifer

Biochar could provide a substitute for fossil coal in industrial applications for which so far there is no alternative to carbon-rich energy sources. An example is the metallurgic industry where a fuel with high carbon content is needed, not only for energy input but also as a reduction agent. Biochar is thermochemically converted biomass, a renewable resource whose carbon content is enriched by heating under the exclusion of oxygen. For biochar production, different processes are technically approved, which all somehow imitate the natural carbonization process. Carbonization can either be done in a water/steam atmosphere or in a low oxygen/inert atmosphere like in nitrogen. Three subprocesses to produce solid biochar can be distinguished: HTC, torrefaction, and pyrolysis. For convenient handling, safety reasons, and maximum energy density, it is necessary to compress the biochar. Densification in form of pelletisation is an established technology for untreated biomass. However, for carbonized biomass pelletisation it has not been optimised and the way how pressure rearranges, compresses, and deforms biochar particles for achieving mechanically durable pellets has not been described in detail yet.

This work attempted to produce a solid energy-dense carbon-rich pellet fuel. Therefore, biochar was produced from three types of biomasses (wood chips, miscanthus, sunflower seed shells) using three carbonisation processes (HTC at 200 °C, torrefaction at 330°C, pyrolysis at 550 °C) and subsequent pelletisation on a laboratory scale using a single pellet press. Three relevant parameters for pressing of classical biomass were varied: water content (12 %, 18 %), binder type (starch, lignin), and binder dosage (1 %, 5 %). Pressing procedure including die dimension and pressure was kept constant to guarantee comparability. The aim was to determine the mechanical durability of produced pellets in form of maximum compressive strength to describe different pellet qualities. In addition, fuel analysis of all biochars was carried out to compare them with fossil fuels. In this respect, it was shown that torrefaction and pyrolysis are suitable processes for converting biomass into coal-like states, whereas it was not possible using HTC. All three raw materials showed carbon contents of around 70 % after torrefaction and between 80 % and 85 % after pyrolysis. Additionally, the heating values were increased proportionately, and the number of volatile compounds decreased.

Regarding pelletisation, it was found that the ability for pelletisation decreases with increasing carbonisation degree. Pellets made from HTC biochar showed the highest strengths and pelletisation was even successful without adding a binder. On the contrary, pellets made from pyrolysis biochar could not be successfully compressed in most cases, even when adding binder up to 5 %. Nevertheless, it was investigated that adding lignin as well as starch had a positive influence on pellet strength for all raw materials and carbonisation techniques. The highest maximum compression strengths were measured for HTC pellets consisting of material with 12 % water content and lignin as a binder. But for pellets made of HTC biochar, there is a higher influence of the original raw material because of the lower carbonisation degree compared with other examined parameters. Additionally, 18 % water content resulted in hard but deformable pellets. They maintained a certain pressure but when it was increased, they were crushed but not broken. For torrefied pellets, the highest compression strength was measured on the sample with 12 % water content and starch as a binder. Here adding of binder was necessary for successful pelletisation, and the strong influence of original raw material as seen with HTC pellets was not observed. The project demonstrates that both binders, starch and lignin, investigated have a positive influence on pelletisation and are even necessary for pelletisation of some biochar materials.

Keywords: *Biochar, Pelletisation, Binders, Fuel characteristics, HTC, Torrefaction, Pyrolysis;*

Green Carbon for Polymer Composites

Stefan Martini
BEST – Bioenergy and Sustainable Technologies GmbH,
Inffeldgasse 21b, 8010 Graz
stefan.martini@best-research.eu
https://www.best-research.eu/

Co-Authors: Norbert Kienzl, Srinivas Lakshmi Narayana Gudi, Oliver Pischler, Uwe Schichler, Vittoria Benedetti, Andrea Brunetin, Markus Grinschgl, Martin Brunner, Wolfgang Felsberger, Marcel Huber

INTRODUCTION

Char originating from biomass can be used as a sustainable carbon additive in the production of polymer compounds with enhanced characteristics [1,2]. The advantages are manifold: firstly, char addition might improve the mechanical, thermal and dielectric properties of the composites and secondly, the substitution of fossil carbon sources reduces the CO2-footprint of the composite production. Furthermore, utilizing organic residues, e.g. from biomass gasification-based CHP-plants, can improve the overall plant economy by generating a valuable side-product. Chars differ considerably depending on their origin. Indeed, initial feedstock, conversion technology, reactive agents and operating conditions strongly affect the final characteristics of the char. In order to assess the suitability of char in polymer composite applications, the investigation of the char, the composite production processes itself and the detailed characterization of the final products are fundamental. One objective of this work is to identify correlations between char characteristics and properties of the final composite to determine requirements on char as an BPC additive to achieve enhanced product qualities.

METHODOLOGY

Within the project, chars of different origin, 1) the solid residue from biomass gasification processes, 2) pyrolytic biochar, are sampled and analysed. Threshold values such as moisture content, volatile content, maximum particle size, enabling subsequent polymer compounding processes are identified. Char parameters like ash content, fixed carbon, elemental composition, particle density, particle size distribution, specific surface area, pore size distributions, structural constitution via Raman spectroscopy are determined to investigate possible correlations to polymer composite properties. Gasifier process conditions are varied in order to assess possibilities to improve the properties of the char residues considering their application as carbon additive in polymers. During the subsequent compounding process char is blended with various thermoplastic polymers resulting in different char-polymer composites. These polymer composite samples are characterized regarding their applicability for specific assignments. Two fields of application are targeted: 1) production of char-polymer composites with adequate mechanical and thermal properties for 3D-printing applications and 2) functionalized utilisation in high voltage (HV) technology as a semiconducting dielectric or a dielectric with high permittivity for targeted field grading in HV-cables and cast-resin isolators.

RESULTS

First screening tests showed that the general processability of char as polymer additive producing filaments for 3D-printing can be achieved, considering boundary conditions regarding the char properties, such as content of volatiles, particle size, and limits of char to polymer ratios. Manufactured polymer composite samples have been analysed on their dielectric properties and showed comparable behaviour to fossil-based carbon sources, such as carbon black, employed as reference additive. Systematic investigations on the influences of operating conditions during biomass conversion and subsequent char treatment steps on the material properties of char itself and the final polymer composite-product are currently in progress. Results will be shown in this contribution.

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Emission reduction, nutrient retention and carbon sequestration in the storage of liquid manure with biochar from wood gasification

Nina Viktoria Schaaf, B.Eng. MSc
MCI Management Center Innsbruck
Maximilianstraße 2, 6020 Innsbruck, Austria
nina.schaaf@mci.edu
www.mci.edu

Lucas Schuchter, BSc MSc, Dipl.-Ing. (FH) Benjamin Hupfauf

Following international and national requirements to combat climate change, the state of Tyrol has set itself the goal of becoming energy-autonomous by 2050. Fossil fuels should be replaced by renewable and domestic energy sources. As an innovative energy supply for renewable electricity and heat, wood gasification in the floating fixed bed process is ideal in order to make the best possible use of the regional biomass wood.

In contrast to the much-noticed geoengineering technologies, this process is not only able to extract carbon from the atmosphere and store it for a long time, but the resulting biochar offers additional potential for added value. One possible application of biochar is as an additive in liquid manure storage. In addition to carbon sequestration, greenhouse gas emissions in agriculture can be reduced, thus contributing to the targets defined in the European NEC directive. In the course of this research, it is investigated whether biochar from the gasification process can be used to minimize ammonia and odor emissions in liquid manure storage. For this purpose, a qualitative assessment of the adsorption properties of biochar is carried out. In addition, the influence on the nitrogen and nutrient cycle is examined, with the aim of achieving an optimal and economical mix between biochar and liquid manure.

Some studies have already proven the ammonia and odor reduction through activated biochar or charcoal from pyrolysis plants. Since biochar is a by-product of the floating fixed bed process and thus has considerable economic value, this biochar in particular is studied as an additive. The alkaline biochar from the floating fixed bed gasification process possesses a particularly large inner pore surface and a beneficial pore structure for its application as a versatile adsorbent. It is expected that more nutrients remain adsorbtively bound on the biochar and thus in the liquid manure, moreover the adsorbed nutrients are protected from leaching and therefore more readily available for plant growth.

For the qualitative and quantitative assessment of the environmental impacts, a life cycle assessment (LCA) according to ISO 14040/ISO 14044 is conducted. Several mechanisms show potential for a positive effect of biochar on the life cycle environmental impacts. Moreover, the decelerated release of the nutrients ammonium and phosphate to the soil can reduce the demand for fertilization and thus prevent eutrophication of water bodies and agricultural soil. However, adverse effects such as a pH increase poses risks of increased ammonia emissions due to an equilibrium shift in the deprotonation of ammonium. The consequence is an increase in the evaporation of ammonia. Depending on various parameters in the production process and treatment of biochars, the influence on a solution's pH value can be either alkaline or acidic. In the case study different scenarios will be evaluated.

Carbon emissions are reduced by the incorporation of biochar into the soil through long-term carbon storage. Thus, carbon is sequestered along the entire cycle from airborne CO_2 via biomass in the form of wood to biochar in the soil. It also seems possible that the entire life cycle of biochar is a carbon-negative process, as has already been postulated in studies. Case studies in course of the LCA examine several possible positive as well as negative effects of biochar addition to liquid manure. By implementing biochar from wood gasification in the storage of liquid manure the SDGs 2, 3, 7, 13, 14 and 15 are actively supported.

Negative emission district heating based on pyrolysis of low-value biomass and biochar soil storage

Tobias Pröll, Jan Kotík, Gerhard Soja and Christoph Pfeifer*
University of Natural Resources and Life Sciences, Vienna
Department of Material Sciences and Process Engineering
Muthgasse 107/H893, 1190 Vienna, Austria
**) tobias.proell@boku.ac.at*
www.boku.ac.at/map/ivet

While most negative emission technologies (NETs) are technologically complex, e.g. requiring carbon capture and storage (CCS) infrastructure, measures in agriculture, forestry and other land-use change (AFOLU) activities and also the application of technically produced biogenic charcoal in nutrient-depleted soils (biochar) can be realized with low technological effort. Thus, these approaches can be much earlier on the timeline compared to CCS-based NETs.

The present contribution addresses the possible revamp of a small to medium scale district heating plant based on biomass combustion into a combined heating and biochar production plant. More than 2100 such heating plants currently exist in Austria with an average heat power output of 0.9 MW producing together 4650 GWh of heat per year. Typically, these plants are fueled with wood chips and current wood chip prices in Austria are around 40 EUR/MWh(LHV). The hypothesis for this study was that lower fuel costs for ligno-cellulosic agricultural by-products compared to wood chips can compensate for the lower fuel to heat efficiency in the biochar production case and that early demonstration projects can be economically beneficial even if the biochar market is underdeveloped and neither relevant revenues from biochar nor negative emission credits can be expected.

A process layout has been developed for a combined pyrolysis and volatiles combustion system producing biochar and heat. Part of the produced heat is used for heating the pyrolysis reactor, but this heat is mostly recovered within the process. Detailed mass and energy balances are presented using a process model implemented in the simulation software IPSEpro. The model has been trimmed to reproduce experimental results in a 3 MW pyrolysis pilot plant using straw as feed biomass as well as small scale continuous pyrolysis results for different agricultural by-products as feed. Air preheating allows for very lean combustion conditions at 900°C in the hot flue gas stream. The cooled flue gas after the pyrolyser heating is at 750°C and the flue gas temperature in the filter is 120°C. Any compression of hot gas streams is avoided using a gas flap for directing more or less flue gas through the pyrolyser heating jacket.

Overall, 30-45% of the fuel power input can be recovered as heat in the hot water system while 45-58% of the fuel power input remain unconverted and leave with the biochar stream. Techno-economic figures for levelized costs of heat (LCOH) are calculated assuming different biomass procurement prices, different revenues from biochar production and different capital cost scenarios. It is shown that demonstration projects for pyrolysis-based heating plants may be operated with economic advantage because of the lower feed procurements costs compared to wood chips. This could then lead to a development of biochar-related markets and create awareness for policies to credit system operators for long-term biospheric carbon storage.

Freitag
20
Jänner

13:30–15:00 Uhr

Workshop

Potenziale und Grenzen des „grünen“ Wachstums in der österr. forstbasierten Bioökonomie

Friday
20
January

01:30 pm–03:00 pm

Workshop

Potentials and limits of „green“ growth in the Austrian forest-based bioeconomy

Workshop: Potentials and limits of “green” growth of the Austrian forest-based bioeconomy

Raphael Asada, Claudia Mair-Bauernfeind, Tobias Stern
University of Graz, Institute of Environmental Systems Sciences
Merangasse 18, 8010 Graz
raphael.asada@uni-graz.at

Lara Crepaz, Manuela Medović, Vanessa Panic, Hannah Seifried, Jonathan Steininger, Simon Unterpertinger

The transformation towards a stronger bio-based economy is on the political agenda in Europe. Besides reduced dependence on fossil resources and lower greenhouse gas emissions, the European Commission expects the creation of new business opportunities and stimuli for the economy and employment in rural areas.
Six students of Environmental Systems Sciences (University of Graz, Graz University of Technology) spent one semester addressing the question of the economic growth potentials and limits of the Austrian forest-based bioeconomy. For this purpose, three widely discussed pathways in research and politics were examined in detail. Based on their findings, the workshop was dedicated to interactively working out raw material, efficiency, and innovation potentials for the Austrian forest-based sector until 2040 and the main factors limit the contribution of these potentials to “green” growth.

Freitag
20
Jänner

13:30–15:00 Uhr

Workshop

Digitalisierung in der Fernwärmeversorgung – durch Daten zu optimierten Systemen & neuen Geschäftsmöglichkeiten –

Special Session von IEA DHC Annex TS4

Friday
20
January

01:30 pm-03:00 pm

Workshop

Digitalisation in District Heating Supply – with data to optimized systems and new business opportunities

Special Session of IEA DHC Annex TS4

Integration of digital processes for optimised operation of and efficient inclusion of renewable heat sources into district heating

Dr. Dietrich Schmidt
Fraunhofer Institute for Energy Economics and Energy System Technology IEE
Joseph-Beuys-Strasse 8
34117 Kassel, Germany
Email: dietrich.schmidt@iee.fraunhofer.de
Homepage: www.iee.fraunhofer.de

Abstract

District heating and cooling (DHC) networks are traditionally operated with a limited number of sensors and actuators to secure the required supply and to optimize economics based on a given high ecologic performance. An optimised heat generation and overall network operation is possible with more information on the demand and flexibility options. An increased deployment of information and communication technologies enables better network management based on real time measurement data and the integration of new digital business processes. For a further development, the promotion of opportunities for the integration of digital processes into DHC systems is required and the role of digitalisation for different parts within district heating and cooling systems needs to be clarified. Digital technologies are expected to make the whole energy system smarter, more efficient and reliable and to boost the efficiency and the integration of more renewables into the system. In the future, digital applications might enable district energy systems to fully optimise their plant and network operation while empowering the end consumer. On the other hand, additional challenges need to be tackled, such as data security and privacy as well as questions about data ownership. The presentation, the paper presents and discusses the first results from the research work within the IEA DHC Annex TS4 on “Digitalisation of District Heating Systems – Optimised Operation and Maintenance of District Heating and Cooling Systems via Digital Process Management”.
https://www.iea-dhc.org/the-research/annexes/2018-2024-annex-ts4

Keywords: digitalization of district heating; operation and maintenance; business processes and models

Opportunities with remote reading of meters for network optimization through intelligent use of data

Dipl.-Ing (FH) Hans Peter Gremel

Kamstrup Austria GmbH

Handelskai 94 - 96, Millennium Tower, A-1200 Vienna

hpg@kamstrup.at

www.kamstrup.com

Co-Authors: Mag. Michaela Glanz, Federico Sepulveda

Heat utilities are faced with an increasing number of complex challenges in their daily business. The handling of large amounts of data is gaining in importance here, from the collection and evaluation to the implementation of measures. Digitization can also be seen as paving the way for a fundamentally changed energy system with decentralized energy generation and networked energy consumption. There are opportunities to optimize the distribution network and to provide the consumer with detailed information about energy consumption. Expectations are a smarter, more efficient, and more reliable energy system.

Some district heating suppliers already have knowledge that they do not fully exploit. In a study by the University of Duisburg Essen on digitalization in heating networks, 80% of the utilities stated that they visualized their network in digital form. Of these, however, only a quarter use this opportunity to gain better knowledge of the network status. The study shows that there is still great potential in identifying avoidable heat losses and finding disturbances in the network operation. Three quarters of the participants agree that heat losses are the greatest challenge for network operation.

Analysis platforms available on the market enable heat suppliers to get the greatest possible added value from the heat meter data. The Danish company Kamstrup, for example, is a leading provider of such platforms. Its analysis platform combines facts about the pipe network, such as pipe length, pipe dimensions, insulation, etc., with the data from the installed intelligent meters in order to create a detailed representation of what is happening in the distribution network. This allows to document supply quality, locate heat losses and leaks, find bypasses affecting system performance and monitor loads and capacities. This new form of transparency means that the production and supply of heat can be better adapted to various factors such as demand, weather forecasts and peak consumption. So only what is actually needed is produced. The environment, consumers and suppliers all benefit from this in equal measure.

Looking at the way current challenges such as climate change or pandemics are being addressed, it becomes clear that solutions are becoming increasingly digital. At the moment we are still at the very beginning and are not exploiting the potential of data. However, if we take our challenges seriously and want to achieve the climate targets - which is probably the most urgent measure - then we cannot avoid going digital and rethinking existing systems, including in the heat supply. A digital heat supply that exploits the full potential of data therefore offers the greatest opportunities for suppliers, consumers and the environment.

Industrial exhibition

Industrial exhibition

Eschlböck: Hacker- und Fahrzeugbau aus einer Hand!

Der spezialisierte Holzhackmaschinenhersteller Eschlböck wurde mit der Entwicklung der Biber Powertrucks VICAN, VICTOR und MARDIX zunehmend auch zum Spezialisten im Fahrzeugbau. Eschlböck treibt den Hacker über ein einstufiges neu entwickeltes Getriebe zwischen Motor und Fahrantrieb an. Die neue Kraftübertragung der Biber Powertruck-Reihe ermöglicht eine hohe Leistungsübertragung bei gleichzeitig geringstem Kraftstoffverbrauch und senkt damit die CO2 Bilanz in der Hackgut-Herstellungskette.

2019 wurden zwei neue Biber Powertrucks MARDIX und VICAN 110 vorgestellt. Die Baureihe Biber 110 wurde mit einem 110 cm Durchmesser großen neuen Hackrotor ausgestattet.

Der große verstellbare Messervorgriff des neuen Z-Rotors und der große Freiraum vor und hinter dem Messer ermöglichen einen angehinderten Materialdurchgang und damit wenig Feinanteil und ein stückiges, grobes Hackgut. Sämtliche Verbindungen des innovativen Rotors sind geschraubt und damit exakt verarbeitet und ermöglichen eine lange Lebensdauer und eine servicefreundliche und zeitgemäße perfekte Austauschbarkeit bei Verschleiß und Fremdkörperschäden. Wie beim bewährten Kombirotor kann sowohl mit dem ganzen als auch dem halben Messersatz gearbeitet und damit Kraft gespart werden.

Der neue MARDIX, ist auf MAN-Basis mit 510 PS und der neuesten Motorengeneration EURO 6d. 2600 Nm Drehmoment lassen auf höchste Leistungswerte im Hackbetrieb schließen. Der neue MARDIX besticht durch seine Geländetauglichkeit mit der 6 x 6 Achskonfiguration, dem 12-Gang Automatikgetriebe und dem Fahren und Hacken vom Bedienplatz aus.

Neu auf den Markt gebracht wurde 2019 außerdem die neue Einsteigermaschine Biber 60 sowie der komplett überarbeitete und seit 1992 bewährte Biber7.

Nähere Informationen unter www.eschloeck.at

Fototext: Vorstellung des neuen Biber Powertrucks VICAN 110 im September am Biberfest 2019

GREEN CARBON

Reducing CO2 emissions is the greatest challenge in the international efforts for climate protection. With our state-of-the-art and fully automated production we are able to store 3 kg of CO2 in just 1 kg of biochar.

So far, the conventional production of vegetable carbon posed two major problems: During carbonization, waste gases which don't meet the European environmental standards occur and the energy lost amounts to up to two thirds of the used raw material.

Both problems can be solved with the modern plant technology developed by POLYTECHNIK. It makes it possible to once more bring the state-of-the-art production of vegetable carbon, which in large parts had been ousted in Europe, closer to this huge sales market and to utilize suitable raw materials close to their point of production.

The most important areas of application are the production of vegetable carbon for soil improvement (Terra preta), the production of high-quality carbon products for the industrial sector, as well as the production of charcoal for the consumer.

Our production plants for vegetable carbon are designed to manufacture products with an especially high carbon content and a low amount of tarry pollutants. The pyrolysis process (transformation of biomass under heat and in absence of air) is achieved by means of a batch process within a retort system.

The waste gases and pollutants which occur during the carbonization process are thermally recycled within a closed cycle. The excess energy which develops during the process can be utilised for heat or energy production. This offers the possibility to meet all relevant environmental standards and to achieve an especially high energy yield from the used raw materials during the carbonization at the same time.

The complete production process, from the supply of the raw materials to the provision of the vegetable carbon, is automated in large parts and performed in shifts, 24 hours per day, 7 days a week.

POLY H.E.L.D. ® Low-emission combustion with extreme air staging

POLY H.E.L.D.® is the combustion technology of the future. The combustion system with extreme air staging, designed as fixed-bed type with counter-current, allows for a low-emission and efficient combustion of various fuels. Dust emissions for wood-based biomass remain lower than 20 mg/Nm3 at 11% O2. A value of below 10 mg/Nm3 can be reached with quality wood chips. Additionally, the POLY H.E.L.D. combustion technology is able to exploit high-ash fuels with relatively low ash melting points at low emissions. The system accomplishes these low emission values with primary measures and without an additional flue gas purification, which makes it a highly economical solution. As a unique design, this system achieved a 20-30% lower NOx emission (compared to conventional combustion plants) without secondary measures like SNCR or SCR.

Fuel is supplied via a screw stoker (or other feed systems). Fuel height is controlled by a redundant measuring system. The plant is started automatically by a hot-air blower.

The grate is a conical grate, specifically developed for this technology by POLYTECHNIK. The new grate is mounted below the fixed bed and is cleaned from ashes simultaneously to the left and the right. In this process, the ash is discarded onto two screws on both ends of the grate and from there it is transported to another ash screw which transfers all of the ashes to a container. The grate frame is water-cooled.

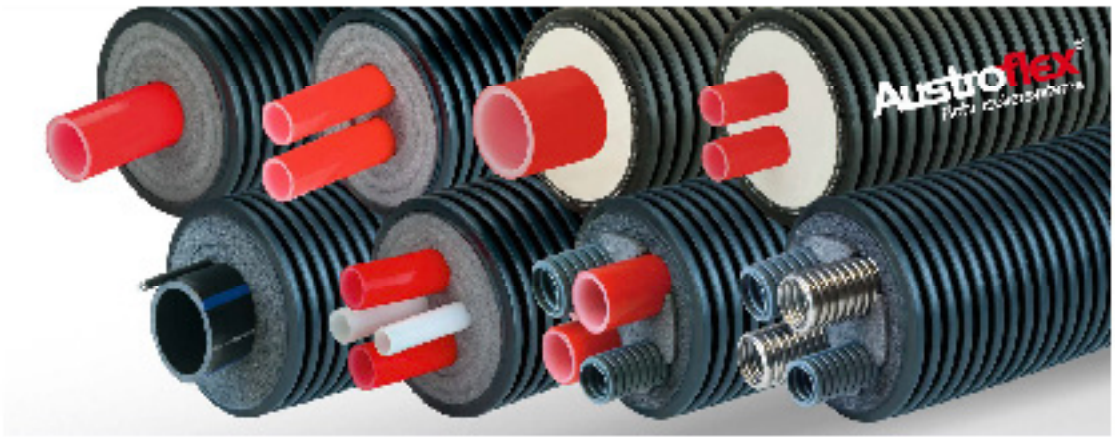
The producer gas is combusted in a newly developed, multi-stage lean gas burner at low emissions with a slight air surplus and high efficiency. Subsequently, the flue gas flows through the heat exchanger and the energy can be used for various purposes: hot air, warm water, hot water, steam and/or thermal oil can be used as heat media.

AUSTROFLEX Rohr-Isoliersysteme GmbH
Firlenstaler Strasse 7
A-9586 Gödersdorf-Villach, Austria.
www.austroflex.com

AUSTROFLEX - the expert for thermal energy networks

Founded in 1985, Carinthia-based company Austroflex has been active for 35 years in technical insulation and the development and production of systems and solutions for the insulation of heating & cooling pipes – made in Austria.

Today, we are recognised within the industry as an expert supplier of flexible Pre-Insulated Pipe Systems, a comprehensive range of thermal Solar Pipe Systems and an assortment of Technical Insulation solutions.



Typical Applications

- District Heating and Cooling networks
- Domestic heating and hot sanitary water
- Biomass/Biogas - CHP installations, Wood and Pellet boilers
- Heat pumps
- Solar thermal systems
- Potable water
- Specific industrial process piping

The `Reverse Power Plant'

SYNCRAFT® wood power plants are climate-positive to support climate protection

Zero emissions are no longer sufficient to counteract climate change. The CO_2 that has already been released must be removed from the atmosphere again, according to the Paris Climate Protection Agreement. To do this, more greenhouse gases must be bound than are released. The climate-positive power plants of SYNCRAFT® are already working with this process: the carbon dioxide remains within the production cycle and is thereby used positively instead of further polluting our environment. The term 'reverse power plant' has been adopted, to highlight the sequestering of CO_2 which is already in our atmosphere.

More than just a wood power plant

The first SYNCRAFT® wood power plant was originally intended to focus primarily on the provision of electricity and heat. The valuable third product, charcoal, was only discovered later and the true potential of it was proven by a 2017 scientific study. As a result, product development was intensified in the Tyrolean town of Schwaz in order to further expand the production of charcoal. By arrangement with the MCI Management Center Innsbruck, a collaboration project was started with the government of Tyrol, also involving Bioenergy 2020+ as a scientific partner. SYNCRAFT® currently offers four different wood power plant models, each of which is adapted to individual customer needs. To ensure that the system is properly installed, SYNCRAFT®'s engineering team takes care of the overall planning, construction and ongoing maintenance of the plant.

Charcoal as a high-yield CO_2 storage medium

The fossil fuels oil and gas are not renewable and release a lot of carbon dioxide during combustion. Wood as a renewable raw material is therefore a good alternative. Although wood contains CO_2 derived from air, part of it remains stored in the charcoal generated at the SYNCRAFT® wood power plant and is therefore no longer released. This creates a profitable and environmentally friendly cycle, because this coal can be used positively: for example, as a feed additive for animal health, similar to coal tablets, or it can bring additional fertility to the soil. This generates additional yield and reduces the use of fertilizers, which in turn counteracts pollution of the environment by overfertilization.

Coal-fired power plants need to pump carbon dioxide into the ground to achieve a negative emissions balance. This not only requires additional energy, but also has no added value and is furthermore unsafe. This is not the case with wood power plants, however, they do generate ash, which is a waste product. A SYNCRAFT® wood power plant on the other hand produces high-quality charcoal instead of ash. Since this provides an additional source of income, this indirectly reduces energy costs and thus enables electricity and heat from forest wood chips to be supplied well below the limits of competitors.

The production of charcoal happens alongside, so to speak, and does not reduce the supply of electricity and heat. The power plants still have a year-round efficiency of 92 %.

The simultaneous provision of sustainable, renewable energy and the storage of CO_2 through the sensible utilisation of the high-quality charcoal is what makes SYNCRAFT®'s wood power plants special. They close the circle without releasing climate-damaging gases into the environment. A good 36 grams of CO_2 are stored per kilowatt hour of energy provided (source: FH Vorarlberg). The CW700-200+ power plant in Dornbirn stored nearly 600 tons of carbon dioxide in 2018. This shows that even a single wood power plant from SYNCRAFT® can make a huge contribution.

Froling: The big name for heat and electricity made from wood and pellets

Innovative solutions with a capacity range from 7 to 3,000 kW

Froling is the big name in automated biomass boilers fuelled by pellets, wood chips or log wood. The family-owned manufacturer offers high-efficiency heating systems (ranging from 7 to 3,000 kW) as well as solutions for fuel storage, tanks, heat exchangers and control systems. It exports to more than 35 countries worldwide and has large-scale manufacturing plants in Austria and Germany. With the experience of over 50 years in heating technology Froling developed the new wood power plant Type CHP, which produces heat and electricity from wood. The CHP50 has received the "Energy Genie" in 2015, which is an Innovation Award of the Ministry of Environment for new products according to the criteria of innovation, energy saving und novelty.

The Froling fixed-bed gasifier CHP 50 is available with an electrical output of 46/50/56 kW and a thermal output of 110 – 115 kW and achieves a total efficiency of more than 85%. The CHP can be installed ready for operation in a container (wood gasification system including safety technology, exhaust gas line and automatic gas flare) and is already put into operation and tested at the production plant of Froling. The other possibility is the indoor-variant where eg. up to 20 units can be installed as a cascade at one location. The first systems are successfully in operation since 2013. The customers are very enthusiastic about the fully automatic betrieb and the high efficiency. The worldwide acting Froling service team can ensure a appropriate on-site support of the CHP system.

Customer care from planning to servicing

The broad range of services provided by Froling is greatly valued by heating engineers, builders, planners, architects and other engineers. No matter what your need, Froling offers a full advice, planning, implementation and after-care service. Experts from around the world take part in training sessions at our training offices. Froling also offers a highly extensive customer service network.

Facts and figures:
Factories: Grieskirchen (AUT), Stritzing (AUT), Marzahna (GER)
Sales/training/competence centres: Grieskirchen (AUT), Munich (GER), Strasbourg (FRA), Bolzano (ITA)
Staff: around 600
Export ratio: over 80 percent
Markets: Europe (our main market); USA; other distributors around the world

Contact details:
Froling Heizkessel- und Behälterbau GmbH
Industriestrasse 12, A-4710 Grieskirchen
Austria tel. +43 (0) 7248 6060
Germany tel. +49 (0) 89 927 926 0
info@froeling.com; www.froeling.com

Feuer und Flamme!
Hargassner ihr Biomasse Spezialist

Hargassner – Ein Familienunternehmen mit Tradition und Herz! Seit über 30 Jahren am Markt und mit mehr als 86.000 zufriedenen Kunden, hat sich die Firma am nationalen und internationalen Biomasse-Markt etabliert.

Firmengeschichte

Vor 30 Jahren überzeugte Anton Hargassner seine Frau, bei dem neu gebauten Familienhaus auf eine selbstgebaute Heizung zu setzen. Als Sohn eines landwirtschaftlichen Betriebs kam kein anderer Brennstoff als Holz in Frage. Da damals die Holzheiztechnik praktisch nicht existierte, entwickelte Hargassner die Hackschnitzelheizung für das eigene Haus damals selbst. Seine Frau überzeugte er damit, dass die selbstgebaute Heizung automatisch mit Brenngut beschickt wurde. Für diese und ähnliche Entwicklungen erwarb Hargassner in den folgenden Jahren Patente und gründete 1984 die Firma Hargassner GesmbH im oberösterreichischen Weng.
Seit 30 Jahren produziert die Firma Hargassner nun schon Hackgutanlagen und seit über zehn Jahren auch Pelletsanlagen. Im Angebot sind Anlagen im Leistungsbereich von 9 bis 200 kW mittels Kaskadenlösung bis 800 kW. Seit 2010 werden auch Stückholzkessel von 20 - 60 kW hergestellt. Neu im Sortiment befinden sich die Stückholz/Pellets Kombikessel. Die Firma verfügt über eine Produktionskapazität von 10.000 Kessel/Jahr. Das Unternehmen beschäftigt mittlerweile über 220 Mitarbeiter. Seit 2013 beträgt die Gesamtfläche der Firma 30.000 m2. In der Produktion sind modernste CNC-gesteuerte Blechbearbeitungsmaschinen, Schweißroboter und eine vollautomatische Pulverbeschichtungsanlage im Einsatz.

Innovation

Ein Hauptaugenmerk im Unternehmenskonzept wird auf die eigene Forschungs- und Entwicklungsabteilung gelegt. Die Produktentwicklung findet innerhalb der Firma Hargassner statt gemäß dem Motto „Vorsprung durch Qualität und Technologie“. Seit 2012 ist das neue Forschungs- und Entwicklungszentrum eröffnet – Größe: weitere 3.600 m2. Das neue Forschungs- und Entwicklungszentrum stellt quasi eine Firma in der Firma dar. Ohne die eigentliche Serienproduktion zu stören, können hier Prototypen gebaut werden. Mit 20 neuen Versuchsständen ist nun auch eine kontinuierliche Forschung möglich. Auf dem Prüfstand stehen nicht nur Heizungen, sondern vielmehr auch neue Brennstoffe und Bedienelemente.

Neuheiten 2017

Hargassner bietet neu Hackgutheizungen im Leistungsbereich bis 330 kW an. Diese sind mittels Kaskadenlösung bis zu 2 MW kombinierbar und vereinen die gewohnte Eco-HK Qualität und Leistungsfähigkeit.

Auch brandneu ist die Erzeugung von Wärme und Strom aus Holz. Mit der neuen KWK Heizung können 60 kW Wärme und 20 kW Strom erzeugt werden. Speziell geeignet ist diese umweltfreundliche Energieversorgung für Gewerbebetriebe, öffentliche Bauten und Nahwärmenetzbetreiber. Zum Einen überzeugt sie durch eine kompakte Bauweise mit sehr wenig Platzbedarf, zum Anderen durch den vollautomatischen Betrieb durch das durchdachte Regelungskonzept – die ideale Lösung für alle, die einen konstanten Energiebedarf haben, wie z.B.: Gastronomie & Hotellerie oder Industriebetriebe, Micronetze etc.

Autor: Marketing Abteilung Firma Hargassner
Firma: Hargassner GmbH, Anton Hargassner Straße 1, 4952 Weng
E-mail: office@hargassner.at
Homepage: www.hargassner.at

BÜRO FÜR ERNEUERBARE ENERGIE
Ing. Leo Riebenbauer GmbH

In Verantwortung für Klima- und Umweltschutz widmet sich die Ing. Leo Riebenbauer GmbH bereits seit Beginn der 1990er Jahre der Planung und dem Engineering von Erneuerbarer Energie. Erklärtes Unternehmensziel ist es, durch die Projektierung und Errichtung von Energieerzeugungsanlagen auf Basis vorhandener regionaler Ressourcen größtmögliche Versorgungssicherheit für Haushalte, Industrie, Gemeinden und ganze Regionen zu schaffen.

Die Tätigkeitsbereiche des Ingenieurbüros liegen in der Entwicklung, Planung und Umsetzung nachhaltiger Energiesysteme für Wärme und Strom aus regenerativen Energiequellen. So sorgt das Unternehmen ***Büro für Erneuerbare Energie – Ing. Leo Riebenbauer GmbH*** in den Bereichen Biomasse-Nah- und Fernwärme, Strom aus Holz und Biogas, Photovoltaik, Solarthermie, industrielle Abwärmenutzung, Energiespeicherung und energieeffiziente Gebäudetechnik national und international für innovative, ganzheitliche Lösungen in der Energieplanung. Darüber hinaus ist das Ingenieurteam der Ing. Leo Riebenbauer GmbH Ansprechpartner für alle Fragen der technischen Optimierung und Effizienzsteigerung bereits bestehender Anlagen.

Energiesysteme aus dem ***Büro für Erneuerbare Energie – Ing. Leo Riebenbauer GmbH*** zählen mittlerweile nicht nur national, sondern auch international zu den Vorzeige- und Referenzprojekten hinsichtlich Erneuerbare Energie und Klimaschutz.

BÜRO FÜR ERNEUERBARE ENERGIE
Ing. Leo Riebenbauer GmbH
Hauptplatz 13
A - 8243 Pinggau
T: +43 3339 25113
M: +43 664 344 87 20 | +43 664 423 10 71
office@riebenbauer.at | www.riebenbauer.at

Postersession

Poster session

Numerical investigation of pressure and holding time on raw density and mechanical durability during biomass densification with an industrial stamp briquetting machine

Roman Adam

DBFZ Deutsches BiomasseForschungszentrum gGmbH,
Torgauer Straße 116,
D-04347 Leipzig,
E-Mail: roman.adam@dbfz.de

Co-Authors: Prerak Khatri, Thomas Zeng, Harald Kruggel-Emden, Volker Lenz

The EU has the goal to reduce 55% of greenhouse gas emissions by 2030 and to become climate neutral by 2050[1]. In order to achieve this goal, the importance of biomass utilization for energy purposes has increased significantly over the past 10 years[2]. In the countries of the United Nations Economic Commission for Europe (UNECE)[3] wood has a continuing predominant role in renewable energy provision. The total wood consumption increased from 193 million m³ in 2007 to 265 million m³ in 2017. This can be attributed to the larger share of wood supply for energy use, which increased from 38.9% in 2007 to 46.9% in 2017 in the UNECE countries. In addition, compared to 2007, the use of wood in the residential sector decreased in proportion to the use of wood in the industrial and electricity sectors. The consumption of densified wood increased significantly (from 16.2 kg in 2007 to 55.2 kg per capita) also caused by the shift from residential to the industrial sector[3]. In this context, biomass densification plays a key role in the use of wood as renewable energy supply. So far, the mainly used biomass consists of wood from sawmill and pulp industry[4]. Sawdust and pulpwood are of a homogeneous and high quality and will therefore be increasingly used for material and bioeconomy purposes in future[4]. For this reason, the future biomass energy use will focus on the processing of residual and waste materials for fuel production. In this case, briquetting could prove to be a more wear-resistant as well as energy-efficient agglomeration process compared to the pelletizing process commonly used in the EU market[5]. With numerical simulations, the biomass briquetting process can be improved with respect to agglomerate quality and process efficiency (throughput, energy consumption, wear). In addition, rapid process adaptation to different assortments as a key factor in biomass processing in the future will be possible.

For this reason, the work focusses on the development of a DEM simulation approach for the numerical aided investigation of a closed mold agglomeration process on an industrial stamp briquetting machine. To achieve this goal, the study of the basic mechanisms (pressure distribution and particle arrangement) of the agglomeration process are first investigated using MatLab. Based on this, a DEM simulation of non-spherical particles will be developed for a semi-industrial stamp briquetting machine with a capacity of 60 kg/h for densification. Crucial is the particle or agglomerate fractures occurring at high plastic deformation as well as its reformation by introducing suitable bond models based on empirical models of press agglomeration. Laboratory or pilot plant trials are required both for the determination of the material characteristics, the empirical modeling of press agglomeration and the validation.

REPLACEMENT OF ENERGY PEAT WITH WOOD FUELS IN FINNISH ENERGY PRODUCTION

Tapio Ranta
LUT University (Lappeenranta-Lahti University of Technology LUT), School of Energy Systems
Yliopistonkatu 34, 53850 Lappeenranta, Finland
tapio.ranta@lut.fi
Antti Karhunen, Mika Laihanen

Between 2018 and 2020, an average of 15 TWh of energy peat was consumed in Finland. Energy peat is used in 260 boilers in Finland, which produce district heat and heat and steam for industry, as well as electricity as cogeneration (CHP) in connection with district heating and industrial heat production. Peat accounts for 3–5% of the energy sources used in Finland, but its importance has been greater in terms of security of supply. With current use in accordance with the 2018–2020 average, the emissions from peat are almost 6 Mt CO_2 per year in Finland, which is 15% of emissions from the energy sector. The use of peat has declined rapidly, by a third, over the period 2018–2020, as fossil fuels are being replaced by renewable energy sources. Peat is typically used in multi-fuel boilers, where various biomass fractions are most used in boilers in addition to peat. Typically, it is necessary to combust some 20–30% of peat or a similar proportion of other sulphur-containing fuels in a power plant boiler to prevent corrosion. In this study, the technical limitations related to peat burning, economic limitations related to the availability of biomass, and socio-economic limitations related to the regional economy were reviewed. By 2040, the technical minimum use of peat will fall to 2 TWh. The techno-economical potential may be even lower, but due to socio-economic objectives, peat production will not be completely ceased. The reduction in the minimum share assumes that old peat boilers are replaced with new biomass boilers or are alternatively replaced by other forms of heat production. Based on the biomass reserves, the current use of peat can be completely replaced by forest chips, but regional challenges may occur along the coast and in southern Finland. It is unlikely that the current demand for all peat will be fully replaced by biomass when part of CHP production is replaced by heat production alone and combustion with waste heat sources.

Technologie- und Förderzentrum
im Kompetenzzentrum
für Nachwachsende Rohstoffe

Real-Life performance of automatically stoked biomass boilers – comparison of type test results and real-life operation in combination with a buffer tank

Sabine Feldmeier
Technology and Support Centre in the Centre of Excellence for Renewable Resources (TFZ), Schulgasse 18, 94315 Straubing, Germany
claudia.schoen@tfz.bayern.de; www.tfz.bayern.de

Co-Authors: *Claudia Schön (TFZ)*, *Hans Hartmann (TFZ)*, *Paul Roßmann (TFZ)*, *Markus Schwarz (BEST)*

Purpose. Automatically stoked biomass boilers are currently only tested following EN 303-5 at constant load conditions. This method does not consider the ignition phases, load changes or burnout phases which may considerably contribute to emissions and reduce the boiler efficiency. To overcome this lack of relevance for real life operation, a standardized load cycle test method was developed within the CycleTest project funded by FNR (22038918) and applied to 10 biomass boilers. The influence of a combination of a buffer with the boiler was also tested applying the novel load cycle test method.

Approach. As a first step, an improved load cycle method with a duration of eight hours was developed considering real life heating patterns of residential buildings as described in VDI directive 4655 (2021). The load cycle introduces a dynamic heat demand with several load changes, to which the biomass boiler shall automatically follow by providing a suitable heat output. Depending on the intelligence of its boiler control, its thermal inertia and on the existence of a heat buffer storage tank, each automatically fed biomass boiler reacts differently to the requested heat demand. Ignition phase, load change and burnout are an integral part of the standard load cycle, thus the dynamic measurement reproduces the real behavior of furnaces in practice.
The novel dynamic method was applied to eight pellet boilers using the same pellet fuel, and to two wood chip boilers using four different fuel qualities, once without a buffer tank and once with buffer tank. Moreover, combustion tests following EN 303-5 were conducted to preveal the differences between steady-state and dynamic boiler behaviour.

Results. Combustion tests applying nominal load to the boilers typically achieved the lowest emissions (CO, OGC and TPM) and highest efficiency. For example, CO emissions ranged between 4 and 74 mg/MJ. In contrast to that the emissions were typically highest when the novel load cycle method without a buffer was applied ranging between 84 and 626 mg/MJ for CO emissions. The combination to a buffer could reduce the number of re-starts of a boiler if needed leading to a clear reduction in emission but still being above the values achieved during nominal load leading to CO emissions between 35 and 240 mg/MJ. The efficiency for the three condensing pellet boilers were lower by 5 to 9 % when the boiler was connected to a buffer tank during the load cycle test compared to the dynamic method without a buffer tank.
Different fuel qualities at the wood chip boilers caused various emission behaviour at steady-state and at dynamic combustion conditions. The connection of the boiler to a buffer clearly reduced CO, OGC and TPM emissions in almost all cases due to the reduction of re-starts especially for the second wood chip boiler. The efficiency of the boilers was lower during the load cycle method compared to the steady state as expected. Only a slight or even no reduction in efficiency was detected if the boiler was connected to a buffer tank.

Conclusion. The application of the novel load cycle method led to elevated pollutant emissions compared to steady-state operation such as during type testing for all boilers. The combination of a boiler with a buffer tank typically reduces the emissions but at the same time the efficiency is also reduced especially for the three tested condensing boilers.

An Improved Method For The Production of Biogenic Silica From Cornhusk Using Sol-Gel Polymeric Route

Clement Owusu Prempeh [1,2], Steffi Formann [1], Ingo Hartmann [1], and Michael Nelles [1,2]*

[1] DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Torgauer Straße 116, 04347 Leipzig, Germany
[2] Department of Agriculture and Environmental Science, University of Rostock, Justus-von-Liebig-Weg 6, 18059 Rostock, Germany
** Correspondence: Clement.OwusuPrempeh@dbfz.de; Tel.: +49-(0)341-2434-523*

Abstract

Porous silica was synthesized from cornhusk using the sol-gel polymeric route and compared with ash obtained from the direct combustion process under laboratory conditions. The unmodified ash from the direct combustion process was dissolved in NaOH for 1 h to form sodium silicate, which was subsequently hydrolyzed with citric acid to yield a silica xerogel. The obtained xerogel was characterized using inductively coupled plasma-optical emission spectrometry (ICP-OES), Fourier transforms infrared (FTIR) spectroscopy, X-ray diffraction (XRD), simultaneous thermal analysis (STA), gas sorption techniques to determine their elemental constituents, functional groups, crystalline phases, thermal stability, and porosity, respectively. The results showed that the synthesized silica xerogel exhibited porous network structures with a high specific surface area and mesopore volume of 384 m^2/g and 0.35 cm^3/g, respectively. The pore size distribution revealed a complete transformation of the pore network structures of the unmodified ash from a monomodal to a bimodal pore system, with micro- and mesopore peaks centered around 1.5 and 3.8 nm, respectively. The ICP-OES results showed that the silica content significantly increased from 52.93 to 91.96 wt. % db after the sol-gel treatment. XRD diffraction confirmed the amorphicity of the silica particles obtained from the sol-gel extraction method. In addition, the STA data showed that the silica xerogel has high thermal stability compared to the unmodified ash, as the latter exhibited poor thermal stability and low textural properties. The high surface area and narrow pore cavity size distribution of the porous silica xerogel make it an ideal substrate for catalysts and an excellent template for growing other nanoparticles within the pores.

Keywords: biogenic silica, combustion, sol-gel, agricultural waste, cornhusk, sodium silicate

Combining biomass and low-temperature district heating networks in the best possible way

Mag. Christian Engel
AUSTROFLEX Rohr-Isoliersysteme GmbH
Finkensteiner Strasse 7, A-9585 Gödersdorf-Villach, Austria
Email: christian.engel@austroflex.com
Web: www.austroflex.com

In the IEA-DHC TS2 project "Implementation of low-temperature district heating systems", leading European experts have developed a guidebook between 2018 and 2021, which aims to maximise the use of renewable energy sources. The economic benefits of low-temperature district heating were investigated based on the cost factors resulting from lower system temperatures.

Cost reduction potentials 5 times higher with low temperature district heating

To show the economic benefit of reduced network temperatures on renewable technologies, the cost reduction gradient (CRG) is used to quantify the economic benefit in terms of the reduced cost per Celsius degree of temperature reduction. Low temperature District Heating enables the extensive use of renewable energy sources. The benefits are up to 5-times higher compared to high temperature solutions.
Repower EU calls for a rapid switch from gas to sustainable energy sources and measures to reduce energy consumption. The IEA-DHC TS2 Guidebook uses real projects to show the economic effects of the most important renewable energy sources, such as biomass, geothermal energy, heat pumps, solar thermal heat or waste heat.
For future district heating networks flexible pre-insulated piping systems are showing promising results in terms of speed of installation, lifetime and overall cost.

Maria Gail Biomass Project: 33% more efficient low temperature heat network

In Maria Gail biomass, solar thermal energy and highly insulated district heating pipes are perfectly combined. The heating plant is a prime example of systematic renewal and adaptation to the highest standards in terms of energy use, CO2 savings and reduction of emissions from biomass combustion. Since the heating plant is located directly in the residential area, the requirements for minimising noise pollution are also very high.
In the years 2020 to 2022, a major expansion of the district heating network with a trench length of over 1200 metres was implemented. For these lines AustroPUR plus pipes with insulation series 3 were used and network losses will be 33 % lower compared to insulation series 1.

IEA-DHC TS2 Guidebook demonstrate the cost-efficient transition to renewables

The IEA-DHC TS2 Guidebook is covering all aspects of low temperature district heating, based on experiences from app. 200 projects all over Europe. With EU initiatives, like RepowerEU in mind, the results are even more relevant for a fast transition to fossil free heating systems.

Download link:
Lyngerud, K., Werner, S., et al. 2021. Implementation of Low-Temperature District Heating Systems, IEA-DHC Annex TS2, Final Report, Fraunhofer Verlag, Halmstad University
https://www.iea-dhc.org/the-research/annexes/2017-2021-annex-ts2

Composting 4.0: From The Automatic Steering Of Compost Turners Towards An Autonomous Plant Management

Max Cichocki [1,], Eva Reitbauer [2], Fabian Theurl [2], Christoph Schmied [2]*
[1] Graz University of Technology, Institute of Logistics Engineering; Inffeldgasse 25/E, 8010 Graz, Austria; itl.tugraz.at
[2] Graz University of Technology, Institute of Geodesy; Steyrergasse 30, 8010 Graz, Austria; tugraz.at/institute/ifg
** Correspondence: cichocki@tugraz.at*

In the European Union, composting and recycling have increased by 80% in the last twenty years [1]. This trend is expected to continue as the EU Green Deal introduces new regulations requiring the compulsory separation and composting of organic waste [2]. Traditional methods of composting will thus no longer be sufficient, as they require manual labor; this includes taking and keeping track of continuous gas composition and temperature measurements of the compost windrows. The adoption of new technologies will become increasingly significant in this field. Therefore, research is currently being conducted to automate composting plant management. The research is carried out in international research projects by Graz University of Technology and its industrial partners.

Within the research project ANTON (**A**utonomous **N**avigation for **T**racked C**o**mpost Tur**n**ers) an automatic steering module for an electrically driven compost turner was developed [3]–[6]. The module uses Global Navigation Satellite Systems (GNSS), an Inertial Measurement Unit (IMU), a stereo camera and odometry from wheel encoders to estimate a highly precise position and attitude of the compost turner in real-time [7]. To account for specific motion characteristics of tracked vehicles a tailored motion model, which accounts for slip, was derived [8]. A robust controller, which was first tested in a software-in-the-loop environment and later adapted in field tests, allows to automatically steer the compost turner along the pre-computed optimal routes.

One of the aims of the follow-on research project ANDREA (**A**utomated G**N**SS-Based **D**ata and P**r**oc**e**ss M**a**nagement for Composting Plants) is to further enhance the system's capabilities by a routing and obstacle avoidance module, i.e. to go from automatic steering to a fully autonomous system. Currently, tests using a laser scanner are being conducted. This enables the compost turner to autonomously find its way to the windrows or the charging station, and allows for operations at night. Another essential aspect is the development of a comprehensive data management system. The system should smoothly acquire, transmit, process, and store data. Our desired objective is to continuously measure the temperature of the windrows during the turning process. We perform geo-referencing to link the collected data to the exact position from which it was collected. Using edge computing, an initial averaging of the values is carried out directly at an Industrial-Internet-of-Things (IIoT) device on the compost turner. Taking advantage of the wireless capabilities of our IIoT device, the averaged values are then securely transmitted to a web server via an encrypted Virtual-Private-Network (VPN), where the data is further processed and stored in a database. Finally, the long-term temperature data is displayed in a user-friendly graphical format and can be easily exported as a report.

In addition to continuous improvements in the areas addressed, current research is also looking at the broader picture. Thus, a sharing system for heavy-duty vehicles in the composting industry is currently being investigated, which is intended to help mitigate the barrier of high acquisition expenditures, especially for smaller plants.[9]

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Biomass power plant Perg

Author: Ing. Leo Riebenbauer
Ing. Leo Riebenbauer GmbH
Hauptplatz 13, 8243 Pinggau
office@riebenbauer.at
www.riebenbauer.at

The Riebenbauer engineering office was commissioned with the project planning and development of the biomass power plant in Perg. The heat is fed into the district heating network of Bioenergie Perg, and the electricity generated is fed into the public power grid of the Perg power station.

Two lines of wood gas combined heat and power plants by SynCraft were used in this project. The wood gasifier together with the combined heat and power plant generates electrical and thermal energy from wood chips. By gasifying the wood chips and using the product gas in a combustion engine with combined heat and power, the energy contained in the raw material is utilized in the best possible way. Wood chips are used as the primary energy source. The energy generated in Perg is 100% sustainable and regional.

Two wood gas combined heat and power plants will be built, each with an electrical output of 500 kWel and a thermal output of 770 kWth.

Total energy generated per year:

kWel = 2*500kW x 8,000h = 8,000,000 kWhel

kWth = 2*740kW x 8,000h = 11,840,000 kWhth

Not only green electricity, but also green heat and biochar are produced from forest wood chips, regardless of the weather situation.

The daily yield of charcoal in Perg will be 9 m3, which means that 4.4 tons of CO2 will be extracted from the atmosphere every day by this plant alone. If charcoal is then put to good use, for example as a soil conditioner in agriculture, this carbon is bound in the long term, because charcoal permanently removes CO2 from the atmosphere and stores water and nutrients like a sponge and slowly releases them back to the plants.

In order to bring the fuel to the necessary quality, four drying boxes for the wood chips are being built. The wood chips are dried using warm air, most of which comes from the low-temperature area of the system. Prior sorting of the forest waste is not necessary. Bark or branches could also be processed, the fuel requirement amounts to 742 kg/h for both systems.

From the drying boxes, the fuel is manipulated onto the sliding floor using a wheel loader or telescopic loader. The wood chips are automatically conveyed from the moving floor to the plant in the HVG room by means of screw systems.

The plant requires a total of approx. 5,900 t of wood chips per year. It works fully automatically. Operating personnel are only used for checks and revision work.

The system is highly efficient, with all useful energy flows together, including the condensation energy from the exhaust gas flow of the gas engine, even achieving a fuel efficiency of well over 90%.

Residential energy supply systems – The end user´s perspective

Doris Matschegg,

BEST – Bioenergy and Sustainable Technologies GmbH

Inffeldgasse 21b, 8010 Graz

doris.matschegg@best-research.eu

www.best-research.eu

Co-Authors: Pascal Liedtke, Rita Sturmlechner, Christa Dißauer, Andrea Sonnleitner, Marilene Fuhrmann, Elisa Carlon, Armin Cosic, Christoph Strasser, Monika Enigl

In order to facilitate the energy transition and the phase-out of fossil energy supply systems in Austria by 2040, civil society should be involved and agree on policy measures. A better understanding of underlying motives of consumers considering a new residential energy supply system (RESS) (heating and domestic hot water, cooling and power) can support the set-up of favorable conditions for an energy transition. Thus, the main interests of this study were motives of consumer decisions for a particular RESS. The impact of gender and intersecting aspects like e.g. income, age or education on the decision was evaluated. Furthermore, interests versus decisions for RESS were compared.

First, qualitative interviews with energy consultants and other stakeholders like installers were conducted to get background information on the decision path and purchase behaviour of potential consumers. Subsequently, a quantitative survey was conducted. The target group were persons who planned to build or renovate a house in the near future or had done so in the previous five years. In total, 24 motives against or in favour of interests and decisions were assessed.

The questionnaire was answered by 169 respondents, 40% of them were women and 60% men. Most respondents were between 30 and 45 years old and lived on the countryside. More than 50% had a university degree. First results show that environment was considered to be the most important motive for the respondents, with a higher share of women. The motives aesthetic appearance, possibility to use locally-available fuel, operation independent from electricity grid and possible operation during black-out were significantly more important to women compared to men. The latter was also considered more important for people with a monthly net household income below 2.000€, compared to an income of more than 5.000€.

The results of the survey, together with a classification of energy supply systems, form the basic framework for a technology-open, unbiased online decision support tool. This tool will fulfil several tasks. On the one hand, it will enable end users to decide on the most suitable technology for their home. On the other hand, cookies will be used to collect further data for an ongoing motive analysis. The tool will use the optimization program OptEnGrid, which enables optimization in terms of costs, greenhouse gas emissions or both. In view of the current crisis and the resulting sharp rise in energy prices, the decision for suitable energy supply systems has become even more important.

Lignin – the future starch?

Valerie Minihold
Holzforschung Austria
Franz-Grill-Straße 7, 1030, Vienna, Austria
v.minihold@holzforschung.at
www.holzforschung.at

Co-Authors: Wilfried Pichler, Martin Weigl-Kuska

Wood can be pelletized without any additive. However, starch offers the opportunity to reduce energy consumtion. It also acts as a binder and, in many cases, as a lubricant. The product properties are clearly defined by the ISO17225 standards and the requirement values from the EN*plus*®. The specific energy consumption, e.g. depends on the plant and raw material.
The disadvantages of starch are obvious. Even if only used with max. 1.8% d.m. and in practice often well below, the energetic use of starch is in conflict with food production. As a primary product of agriculture, starch has a not inconsiderable carbon footprint. In addition, the scarcity of raw materials has led to massive price increases in the last two years. Kraft-lignin might be an alternative!
The chemical composition of lignin as a commercial product or as an experimental raw material is central. The first table provides an overview of the scatter range of some commercial, and thus not yet optimized, lignins. The results show clear favorites with clear feasibility as well as some clear No-Gos so fare.

Ash content [%]	EN ISO 18122	Lignin	0,61 - 3,65
Ash melting (deformation temperature) [°C]	CEN/TS 15370-1	Lignin	850 - 910
Sulphur content [%]	EN ISO 16994	Lignin	0,93 - 2,69
CO off-gassing after 3 h [ppm]	ISO/FDIS 20048-2	Pellets with / without Lignin	410 - 830 / 840 - 940

Applicability of such lignins was assessed in practical trials. In a first step, the powerful Single Pellet Press (SPP) process enabled eight different additives to be modeled in interaction with raw material moisture and process temperature. The 300 individual tests required for this could be carried out with a small amount of raw material under strictly controlled test conditions. In these tests, process parameters such as friction work or product parameters such as mechanical durability can be estimated to a good approximation.
The process energy required to transport material through a SPP die was analysed and compared to further wood species without additive. *Lignin a* showed a high similarity to beech, with a high process energy. *Lignin b* behaved similarly to starch and related to pure spruce wood. This type of lignin extracted in the laboratory also showed good properties for improving mechanical durability and was therefore used as a basis for the development of a modified lignin. Further trials were performed in the biomass pilot plant. Selected results from SPP and pilot plant trials were standardized and are shown in the second table.

	Friction work Single Pellet	Max. flow force Single Pellet	Specific energy Pilot Plant
Lignin c	1,21	0,66	0,00
Lignin d	0,55	0,76	-0,21
Starch	-1,98	-0,55	-0,51

The results of the SPP cannot be directly transferred to the pilot plant level, but point in a similar direction. Especially lignin d, showed at this point already without modification a potential to follow in footsteps of starch. It was therefore subsequently tested in industrial trials.
The results so far show one thing clearly: Existing lignin types are currently not able to keep up with the references examined, but they have potential. The reduction in CO off-gassing represents an exciting additional benefit. The results so far thus confirm that lignin can only be successful as a pressing aid for pelleting on the basis of targeted engineering.

proPellets Austria project KraftPell (FFG-Nr. 884529) is supported by FHP - Cooperation Platform Forest Wood Paper and seven companies. Co-research: Slovak University of Technology in Bratislava (lignin modification) and BEA Institute for Bioenergy (chemical analysis).

Protein extraction for improved value chain for ley grass for ethanol and biooil production

Carina Gunnarsson, RISE Research Institutes of Sweden, Box 7033, 75007 Uppsala, Sweden. Phone: +46 10 5166932, E-mail: carina.gunnarsson@ri.se

Maria del Pilar Castillo, RISE Research Institutes of Sweden, maria.castillo@ri.se; Lovisa Eliasson, RISE Research Institutes of Sweden, lovisa.eliasson@ri.se; Emma Johansson, RISE Processum, emma.johansson@processum.se; Epameinondas Xanthakis, RISE Research Institutes of Sweden, epameinondas.xanthakis@ri.se

Abstract

Ley, i.e. different species of grass and leguminous plants, is grown on 44% of Sweden's arable land. Ley has many added values, both for crop rotation and for landscape diversity. In Sweden, ley is an underutilized resource, and is a promising raw material that does not compete with food production. In this project, financed by the Swedish Energy Agency, we studied an agricultural biorefinery system using ley and straw and combining extraction of high-value components such as proteins with biofuel production. In a first step the ley is fractionated and the liquid fraction goes to extraction of primarily protein whereas the solid fraction is used for ethanol and biooil production and the remaining organic matter is used for biogas production. The harvest and supply of ley to the biorefinery were described and lab scale tests were focused on extraction of high value components, ethanol, biooil and biogas production.

Lab scale tests carried out by using fresh and ensiled timothy after screw pressing for characterization, identification of valuable components for food applications. Methods to increase yield and quality of the protein concentrate were also evaluated. The crude protein yield in the liquid fraction found to be higher for ensiled timothy compared to fresh but showed lower levels of true protein due to polypeptide chain degradation into smaller peptides and free amino acids during the ensiling process. The amino acid composition of both ensiled and fresh timothy was similar to that of soya beans. Protein precipitation of the liquid fraction from fresh ley using heat coagulation and isoelectric precipitation followed by centrifugation resulted in similar protein content in the concentrate. Tests with enzymatic treatment combined with pressing increased the protein yield of the process. Due to the protein degradation during ensiling a protein concentrate could not be precipitated using the same methodologies.

The solid fraction after screw pressing was tested for ethanol and/or biooil production through HTL, hydrothermal liquefaction. For ethanol production, screw pressing as only pretreatment method before the fermentation was not enough to achieve a sufficient release of sugar. Therefore, an extra pretreatment using steam explosion was added and resulted in a sufficient level of sugar content for fermentation. HTL, hydrothermal liquefaction, was tested as a technology to produce biooil from the solid fraction, the process found to be stable and the bio-oil produced was of high quality with high energy value and low ash content.

The potential to utilize the organic matter remaining in the residual water fractions after protein extraction (brown juice) and biooil production was tested for methane production in lab tests. The biogas production from the brown juice was fast showing that the remaining carbon was easily available. The HTL residual water behaved differently, since the methane production was very slow to start which indicated the presence of substances with toxic effects on the methane producing microbes.

BIOFIT case studies - How to adapt existing industrial facilities

Doris Matschegg,

BEST – Bioenergy and Sustainable Technologies GmbH

Inffeldgasse 21b, 8010 Graz

doris.matschegg@best-research.eu

www.best-research.eu

Co-Author: Dina Bacovsky

The BIOFIT project is a HORIZON 2020 initiative that aims to facilitate the introduction of bioenergy retrofitting in five specific industries, namely first-generation biofuels, pulp and paper, fossil refineries, fossil firing power and Combined Heat and Power (CHP) plants. Within the project ten case studies for retrofitting existing facilities have been studied in detail.

Increasing the share of biomass in industry supports Europe in becoming independent from fossil fuel imports, in ensuring security of supply and in stabilizing energy prices. Spurred by innovation, bioenergy technologies are becoming more advanced and diverse, leading to the production of a variety of advanced transport fuels (first- and second-generation bioethanol, biodiesel and bio-kerosene), intermediate bioenergy carriers and high efficiency, low carbon emission production of power, heating and cooling. Besides erecting entirely new bioenergy plants, retrofitting existing facilities, meaning the replacement of part of a plant or installation with state-of-the-art equipment, can be a good alternative solution to replace fossil fuels or to upgrade outdated renewable technology. Retrofitting often results in lower capital expenditure (CAPEX), shorter lead times, faster implementation, lower production time losses and risks.

Within the project, ten case studies for retrofitting existing facilities have been studied in detail. These case studies include the retrofitting of a first-generation ethanol facility to produce second-generation ethanol, the retrofitting of the same facility to produce alcohol-to-jet sustainable aviation fuel; retrofitting of a pulp mill to the production of ethanol from brown liquor, retrofitting of a pulp mill to produce biocoal from wastewater sludge; adapting a refinery to co-process pyrolysis oil in the FCC for the production of fuels with biogenic fraction, adapting another refinery to co-process used cooking oil in a hydrotreater unit for the production of diesel fuel with biogenic fraction; retrofitting a coal-fired power plant to allow biomass co-firing, converting another coal-fired power plant to the use of thermally treated biomass; converting a combined heat and power plant to the use of biomass, and converting a fossil oil boiler for district heating to the use of bio-oil. These retrofitting options are assessed in close cooperation with the companies that operate the respective existing facilities; some companies have the firm intention to build the assessed retrofit, while others use the case studies as basis for their investment decisions.

The case study assessments cover most of the options for integrating biomass into existing industrial facilities, promising an easy to implement route to rolling out these technologies and making a significant impact on GHG emissions in the near term. The assessments include technical process description, supply chain analysis, environmental analysis, techno-economic assessment and market assessment. We will present highlights from these case studies, describe challenges that we have encountered and lessons learned about how existing industries can be adapted to use more biomass and produce more bioenergy and biofuels.

EVALUATION OF SUGAR CONTENT AND BIOFUEL POTENTIALS OF *Eichhornia crassipes, Pistia stratiotes, Salvinia molesta.*

Abdullahi, A.F[1].; Maikaje, D.B[2]; Denwe, S.D[3] and Muhammad, M.N[4].*

1. *Post Graduate, Department of Biological Sciences, Nigerian Defence Academy, Kaduna.Sayyid9dec@gmail.com*
2. *Department of Biological Sciences, Nigerian Defence Academy, Kaduna.*
3. *Department of Biological Sciences, Nigerian Defence Academy, Kaduna.*

4. Department of Chemistry, Nigerian Defence Academy, Kaduna. (08034517413)*

ABSTRACT

An evaluation of sugar contents and biofuel potential of *E. crassipes, P. stratiotes and S. molesta* was carried out using oven drying at 105^0C for 6hours, pulverization, hydrolysis, overliming, detoxification and fermentation. The result shows that maximum ethanol yield of *E. crassipes* is 25ml, 25ml for *P. stratiotes* and the least content of 20ml was found in *S. molesta* after 21days of fermentation with means yield of 18.3, 17.6 and 15.0 respectively. Determinations of xylose and glucose content were achieved using phloroglucinol assay and Dinitrosalicylic assay respectively. The amount of glucose and xylose detected in *E. crassipes, P. stratiotes and S. molesta* were (0.08, 0.11g/l), (0.07, 0.09g/l) and (0.04, 0.07g/l) respectively. The variation in the amount of sugars, determined the amount of ethanol yield. The macrophytes used in this study represent a good source of Biofuel production.

Key Words: - **Fresh water biomass, Biofuel, Fermentation, phloroglucinol assay, Dinitrosalicylic assay.**

Greenhouse gas balance of Biogas Wipptal GmbH and cooperating dairy farms

Stephan Maier
STRATECO OG
Ruckerlberggasse 13
8044 Graz, Austria
stephan.maier@strat.eco
www.strat.eco

Co-Authors: Manfred Szerencsits, Nicolas Katzer

Goal
The aim of the study is to determine and balance the greenhouse gas emissions of dairy farms (including their respective on-farm characteristics, e.g. own electricity generation) that supply slurry and solid manure to Biogas Wipptal GmbH (status quo).

Method
The method used was the calculation standard for individual operation climate balances (BEK) in agriculture, climate gases according to the IPCC AR 4 report, and adapted to the corresponding system boundaries of the farms considered (dairy farms and biogas plant).

Scope
The status quo of the dairy farms including manure deliveries to the biogas plant, credits for the production of biogas electricity and manure pellets and for further operational renewable electricity production are taken into account. In a hypothetical comparison scenario, the dairy farms without a biogas plant are shown if any farm manure surpluses had to be transported away.

Results
The results include the greenhouse gas emissions per kg ECM (Energy-Corrected Milk) for 6 of 66 dairy farms participating in the biogas plant Wipptal for the year 2019. Starting from dairy farms without further utilisation cascades or expansion stages (biogas, fertiliser use and renewable electricity generation), each additional expansion stage results in an improvement in terms of greenhouse gas emissions, calculated in CO_2e (= CO_2 equivalents).

For the 6 farms balanced, this results in the following ratio of specific greenhouse gas emissions per kg ECM. The status quo: farms incl. biogas plant results in 533 to 826 g CO_2e per kg ECM. If the credits for own electricity generation from renewable energy (photovoltaics, hydropower) are also taken into account, the CO_2e are reduced to 197 to 656 g per kg ECM. In the comparison scenario: dairy farms without biogas plants, the amount would be significantly higher at 740 to 939 g CO_2e per kg ECM. The level of emissions is decisively determined by the lifetime milk yield per cow.

A look at the specific greenhouse gas emissions per dairy cow, demonstrates the ratio. With the status quo: farms incl. biogas plant, this is between 5.5 and 8.4 t CO_2e per dairy cow. If the credits for own electricity generation from renewable energy (photovoltaics, hydropower) are also taken into account, the CO_2e are reduced to 1.8 to 8.1 t per dairy cow. In the comparative scenario: dairy farms without biogas plants, the amount would be significantly higher at 6.6 to 9.4 t CO_2e per dairy cow.

Conclusion and potential for improvement
The cooperation of dairy farms with the Wipptal biogas plant has a favourable effect on the climate balance of the dairy farms. This is because the residues from milk production are currently used to generate electricity and heat and to produce fertiliser pellets to substitute mineral fertiliser. Emissions can be further reduced by using fuel as biomethane or bio-LNG and by producing dry ice. Apart from this, there is still potential for optimising farm management practices (e.g. collection intervals and storage of farm manure and digestate, use of biomethane and bio-LNG for management and transport, optimisation of feeding) with which the climate balance can be improved. By increasing the use of dual-purpose breeds with high lifetime milk yields and expanding cooperation with suckler cow farms in the fattening of male calves, the total greenhouse gas emissions from milk and beef production could again be significantly reduced.

Feasibility study
Large-scale solar systems in Bruck an der Mur

Author: Ing. Leo Riebenbauer
Ing. Leo Riebenbauer GmbH
Hauptplatz 13, 8243 Pinggau
office@riebenbauer.at
www.riebenbauer.at

The Riebenbauer engineering office carried out a feasibility study for the Brucker Biofernwärme (Brucker bio district heating) as part of the "Solar thermal energy - large solar systems" program.

Initial situation Bruck an der Mur:
Since 2008, a biomass heating plant with two biomass boilers with a nominal heat output of 4,000 kW each, including a district heating network for year-round heat supply, has been operated in the municipality of Bruck an der Mur. In 2012, the heat supply was optimized to a maximum output of 16.6 MW of waste heat by extracting waste heat from the local paper mill Norske Bruck an der Mur.

A second biomass heating plant is currently being planned. This biomass heating plant will be built at a location where a large solar system can be set up in the immediate vicinity. Due to the current massive expansion in Bruck, a feasibility study was carried out to reduce the future need for biomass. Calculation and simulation variants: The aim of this feasibility study was to calculate the optimal size of a solar concept including seasonal heat storage. At the same time, the integration of the solar thermal system into the existing district heating network was planned.

Two variants were developed for this purpose.
Variant 1 is a "large-scale solar thermal system with long-term storage". For comparison, in variant 2, a smaller "thermal solar system for summer off-peak periods with short-term storage" was also examined.

Variant 1: collector area 49,875 m2 / storage volume 150,000 m3
Variant 2: collector area 14,949 m2 / storage volume 5,000 m3

Results:
The feasibility study carried out in Bruck an der Mur is intended to show potential for future heat supply concepts in cities.

Large-scale systems can be implemented economically, but such a project must be viewed in the long term. It makes sense to plan in expansion stages.

In order not to use the areas solely for solar thermal systems, it would make sense to use the green areas for agriculture at the same time. The design of the solar collectors was therefore planned on the lower edge 1 m above level, for example to enable livestock such as sheep or chickens to be kept underneath.

In order to finance such a project, a contracting model could be set up. On the other hand, it would also be possible to involve the population of Bruck an der Mur in this project and to initiate citizen participation models for solar thermal energy.

Due to the energy crisis and the need to deal with the raw material wood even more efficiently in the future, the relevance of large solar systems is increasing enormously.

Biomethane market dynamics & framework conditions in European and Mission Innovation countries (the project GreenMeUp)

Author: Myrsini Christou
Organization: CRES – Center for Renewable energy Sources and Saving,
Address: 19th km Marathonos Avenue, 19009 Pikermi, Greece
E-mail address: mchrist@cres.gr

Co-Author: Teresa Ridolfi
Organization: ETA Florence Renewable Energies
Address: Via Antonio Giacomini 28, 50132 Florence, Italy
E-mail address: teresa.ridolfi@etaflorence.it

Introduction:

Green gas **biomethane (bioCH4) and biohydrogen (bioH2)** are expected to be key contributors towards the decarbonisation of the EU energy system[1], as renewable gasses are injected to the Natural Gas (NG) grid. But the extent of that growth strongly depends on the market and policy environment as well as on societal acceptance. The EU Green Deal and the Fit for 55 package bring new opportunities to scale-up biogas, bioCH4 and BioH2 deployment in Europe. However, policy at Member State level is not always adequately tailored to the actual capacities of raw material and industrial infrastructure as well as market specificities.

Objectives: The ultimate objective of GreenMeUp is to facilitate the wider market uptake of biomethane in the European energy and transport sectors by strengthening the market in countries with slower market development policies.

This will be achieved by bringing together: The European Biogas Association that will bring forward good practices and lessons learnt from countries having the highest market shares; a set of advanced countries (Germany and Italy) with improved biomethane market uptake and developed policy and institutional frameworks to actively participate in exchanging practical knowledge and experience; a set of target countries with lower development rates in the respective issues (Greece, Spain, Poland, Latvia, Estonia and Czech Republic) which would benefit from stronger bioCH4 market and policy measures.

Results:

A comprehensive overview of production routes (feedstocks, technologies) and end-uses of renewable gasses as well as existing policy frameworks in advanced European and Mission Innovation countries, as well as in the target countries is being prepared. Good practices and lessons learnt will be discussed in the paper.

GreenMeUp website: https://www.greenmeup-project.eu/
GreenMeUp LinkedIn: https://www.linkedin.com/company/greenmeup-project

[1] EC, European Energy Security Strategy - Communication from the Commission to the European Parliament and the Council, vol. 2014, COM, 2014, p. 330.

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FlexSNG H2020 Project: Flexible Production of Synthetic Natural Gas and Biochar via Gasification of Biomass and Waste Feedstocks

Authors: Sanna Tuomi, Esa Kurkela, Minna Kurkela, Ilkka Hiltunen
Organization: VTT Technical Research Centre of Finland
Address: Ltd, PO Box 1000, FI-02044 VTT, Finland
Email address: Sanna.Tuomi@vtt.fi

Author: Emma Fromant
Organization: ETA Florence Renewable Energies
Address: Via Antonio Giacomini, 28, 50132, Firenze, Italy
E-mail address: emma.fromant@etaflorence.it

Abstract:

EU-H2020 project "FlexSNG" is currently developing a novel gasification-based process that can flexibly produce pipeline-quality biomethane alongside high-value biochar and renewable heat from low-quality biomass residues and biogenic waste feedstocks. The target is at medium-scale conversion plants with 50-150 MWth feedstock input that allows the use of local biomass residues and biogenic waste fractions without heavy transport logistics. The key innovative technology that essentially forms the core of the FlexSNG concept is the flexible gasification process that can switch between two operation modes according to price signals and market demand: 1) co-production of biomethane, biochar and heat, and 2) maximised production of biomethane and heat. This approach also makes possible to use a much wider range of lower quality biomass residues and wastes as feedstocks compared to state-of-the-art gasification technologies. The produced biomethane can be readily injected into the existing gas infrastructure for distribution to various end-consumers in the transport sector (gas vehicles,heavy-duty trucks, shipping), heat/power production, industries, households and combined heat and power (CHP) plants. The co-produced biochar, on the other hand, is a solid and therefore easily storable bioenergy carrier that can be used to displace fossil feedstocks in the wider energy system (e.g. thermal generation, co-firing) and industry (e.g. iron and steel making) but also has wide markets in material use (e.g. soil amendment, activated carbon). The FlexSNG plant is integrated with local energy systems to utilise by-product heat from the process as renewable steam to industry, or as renewable district heat to communities. Such heat integration enables high overall efficiency (>80%) that is comparable to combined heat and power production plants.

The key innovative unit in the FlexSNG process is the novel gasifier that can flexibly switch between co-production of biochar and syngas and maximised production of syngas. The Bubbling Circulating Fluidised-Bed (BCFB) gasifier employed in FlexSNG is based on an innovative combination of the two fluidised-bed reactor types: a bubbling and a circulating fluidised-bed. The BCFB gasifier was originally developed and patented by VTT in the early 2000's. The technology was specifically designed for lower grade feedstocks and tested back then in fuel gas applications with waste fuels (air-blown mode). In the current project, the BCFB gasification technology is now adapted to co-production of biochar and synthesis-quality gas, using steam and oxygen as fluidising gases.

FlexSNG website: https://www.flexsng.eu/

FlexSNG LinkedIn: https://www.linkedin.com/company/flexsng-project-h2020/

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Clean and efficient microCHCP by micro turbine-based hybrid systems

Authors: Teresa Ridolfi, Stefano Capaccioli
Organization: ETA-Florence Renewable Energies
Address: Via Giacomini 28, Florence 50132, Italy,
E-mail: teresa.ridolfi@etaflorence.it, +39 055 5002174
Co-Authors:
Søren Løkke, Aalborg University, Denmark
Michel Delanaye, MITIS, Belgium
Bert Van De Beld, BTG-Biomass Technology Group, Netherlands
Hans Korteweg, COGEN Europe, Belgium
Ward De Paepe, University of Mons, Belgium
Ralph Hermann, Fahrenheit, Germany
Gerrit Füldner, Fraunhofer ISE, Germany
Siri Harboe-Minwegen, OWI Aachen, Germany

Aim and approach used:
The main aim of the Horizon Europe Fit4Micro Project is to develop a microCHP unit running on sustainable liquid biofuels. The application of this unit is foreseen at multi-family houses and at remote or off-grid locations. This technology will lead to very high electrical efficiencies (>40%) and a flexible heat/power ratio. Moreover, the usage of a truly advanced and RED2 compliant biofuel will guarantee a high GHG emission reduction. This flexible hybrid energy system is based on a double-shaft micro gas turbine (mGT) combined with a novel humidification unit, and will be able to provide renewable heating, cooling and power production, mainly for domestic usage.

Scientific innovation and relevance:
The technology developed in Fit4Micro is based on a hybrid heating system. These systems have several advantages compared to pure electrically driven ones: they can supply heat at a similar temperature to gas or oil boilers, with little impact on efficiency. For this reason, they are particularly attractive in the retrofit market for hard-to-treat homes. In order to implement the Fit4Micro solution, the research's starting point is the innovative Intercooled Regenerative Reheating Gas Turbine (IRRGT) prototype from MITIS, which works with flameless combustors that can achieve very low emissions and high fuel flexibility. This turbine will be improved during the project implementation, aiming at increasing its current design efficiency from 29.6% to 40%. Then, a prototype combustor will be developed and built, in order to advance flameless combustion with liquid biofuels for use in the turbine. The Fit4Micro project investigates those systems in which the solution provides an improvement to the climate performance. These results will assist decisionmakers in implementing the technology in order to obtain the highest emission reductions.

Expected outcomes and results
The development of this hybrid heating system significantly increases the socioeconomic and environmental sustainability in household sector, replacing fossil fuels with biofuels. Moreover, activities in Fit4Micro contribute to increase the share of renewables at consumer level: one of the main outcomes of the project concerns the production of low-cost biofuel with good technical characteristics.

Fit4Micro LinkedIn: https://www.linkedin.com/company/fit4micro/

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A promising material stream? Activated carbon from municipal residues for micropollutant adsorption

Dominik Bosch
Josef Ressel Centre for the production of powdered activated carbon from municipal residues
Department of Environmental, Process and Energy Engineering
MCI | The Entrepreneurial School
Universitaetsstrasse 15
6020 Innsbruck, Austria
dominik.bosch@mci.edu

Co-Authors: Jan O. Back, Angela Hofmann, Anke Bockreis

Rising populations and industrialisation have drastically increased environmental pollution by heavy metals (HMs) and organic micropollutants (OMPs). Due to the low natural degradation rate in water bodies and the incomplete degradation performance of municipal wastewater treatment plants (WWTPs), there is an eco-accumulation of HMs and OMPs. Activated carbon contact basins in wastewater treatment plants are supposed to provide a remedy. However, the use of fossil feedstocks in the production of activated carbon (AC) has recently fallen into disrepute. For the past 2 years, the Josef Ressel Centre at MCI Innsbruck has been working on the production of functionalised activated carbon from municipal residues for use in wastewater treatment plants. Single-stage pyrolysis of biomass impregnated with $ZnCl_2$ has proven to be an effective activation method for the production of functionalised activated carbon. Municipal waste wood and forest wood chips were used as biomass. These types of AC are characterised by high specific surface areas (up to 1960 $m^2 g^{-1}$) and the presence of oxygen-containing functional groups. In comparative adsorption tests, AC produced by $ZnCl_2$ impregnation were compared with commercially available AC as well as a gasifier char from a wood gasification process and a subsequently activated gasifier char. 6 different HMs (Zn, Ni, Cd, Cu, Pb, Al) and 6 OMPs (benzotriazole, carbamazepine, diclofenac, metoprolol, sulfamethoxazole, valsartan) were chosen as lead substances for adsorption capacity. Chemically impregnated AC, for example, showed an adsorption capacity of up to 25.5 mg g^{-1} for Pb; in comparison, a commercially available AC adsorbed only 1.61 mg g^{-1}. With regard to OMPs, similar adsorption capacities (220-300 mg g^{-1}) were measured in each case. Overall, chemically impregnated AC from municipal residues offers a regionally available alternative for adsorption of pollutants in WWTPs. For large-scale application, production on a larger scale should be investigated.

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Capturing CO2 with Hot Potassium Carbonate: an appealing solution for Biomethane / Syngas Applications and Flue Gas decarboning

Walter Giacopini

Green Methane

Via Trieste 230, Ravenna

walter.giacopini@greenmethane.it

greenmethane.it

Generalities

The step of CO_2 Removal is essential in Biomethane production, regardless of the pathway of its generation (through biogas-anaerobic digestion or syngas-gasification route). In both the ways, CO_2 needs to be eliminated to higher the calorific value of the gas and meet the quality of Natural Gas standards.

Several CO_2 Removal Technologies are available on the market (membranes, PSA, water washing, chemical washing, cryogenic), with different cost and performances. The optimal selection for the CO_2 Removal in each Project depends from a number of factors like: size, environmental performance, climate, energy cost, integration with existing infrastructure, footprint.

Until few years ago, among the chemical washing for Biomethane Upgrading, organic or amine-based solutions only were considered. Amine solutions have the best performance in CO_2 capture as well as an outstanding off-gas purity. However, they have very high thermal energy demands for solution regeneration. Moreover, there are many rising concerns about their environmental impact: those solutions are highly toxic and volatile, leading to potential risk associated with environment contamination and solution management.

Now, thanks to the Green Methane introduction of Hot Potassium Carbonate (HPC) solution into the Biomethane market, there is an environmental friendly alternative for Upgrading based on chemical washing. Thanks to the massive experience of Giammarco-Vetrocoke (GV) in design and licensing of HPC schemes for CO_2 capture in any industrial field, Green Methane has putted into the market a solution that has demonstrated to be as good as amine washing in terms of CO_2 capture and off-gas purity performance, but less demanding in heat demand and making use of a non-toxic solution.

Typical Figures in Biomethane field

In biomethane applications, Green Methane technology has now 13 References. The following parameters are typically met:

Electric Energy Demand: <0.2 kWh/Nm3 of biogas

Net thermal Energy Demand: <0.1 kWh/Nm3 of biogas

Residual CO_2 in Biomethane: <1%

Off-gas purity: CO2>99.9% dry basis (CH4 slip<0.1%)

Other applications

The Giammarco-Vetrocoke HPC Process has been recently applied in four FEED for Gasification Projects. The technology has been selected thanks to its robustness, the excellent off-gas purity, the low energy demand, and the low capex associated with the CO_2 Removal. Now Green Methane is in position to offer turn-key CO_2 Removal Plants based on the GV HPC Process.

Green Methane utilized GV HPC Process in a novel demo application capturing CO_2 from Flue Gas coming from an incineration process. The Plant is located in a Waste to Energy complex in North Italy, commissioned in July ’21 and operating since then. A stream of Flue gas prior to the gas stack is sent to the plant to capture the CO_2 and convert it into sodium bicarbonate for reutilization within the factory itself.

Experimental investigations of nitrogen oxide emissions from biomass combustion employing selective non-catalytic reduction in a lab-scale grate firing reactor

Gabriel J. Roeder
Chair of Energy Systems, Technical University of Munich
Boltzmannstraße 15, 85748 Garching b. Munich, Germany
gabriel.roeder@tum.de
www.epe.ed.tum.de/es/en/homepage/

Co-Authors: Stefan Retschitzegger, Sebastian Fendt, Hartmut Spliethoff

Combustion processes produce harmful nitrogen oxide gases (NO_x) which contribute in the formation of acid rain and smog, as well as in the reduction of the ozone layer in the stratosphere. Moreover, the tropospheric ozone layer is affected by these gases, which additionally irritate and damage the respiratory organs of human beings. Reducing and keeping the emission of oxides of nitrogen at a minimum is therefore highly important, especially with increasing combustion of different types of biomass and biogenic residue for heat and energy production. These fuels can have a high nitrogen content in some cases, leading to higher NO_x emissions. In this study we investigate economic methods to reduce the NO_x emissions from wood pellet combustion in a grate firing configuration by employing selective non-catalytic reduction (SNCR). The effects of SNCR on the emissions are investigated by flue gas analysis. These effects are systematically studied regarding temperature, initial and total air stoichiometry, and reduction agent stoichiometry. The slip of ammonia, when implementing SNCR, is also taken into consideration and the influence of the parameters on the intermediates of NO_x is investigated in a fixed be reactor. By implementing SNCR, the emission of NO_x can be minimised. In future work, we will investigate the effects on NO_x emissions in other firing concepts, e.g. pulverised entrained flow combustion, and expand on the acquired knowledge through modelling and simulation of the reactors in order to scale up the NO_x emission reduction methods.

Technological carbon from industrial tea waste biomass

Gökçen Akgül
Recep Tayyip Erdogan University, Engineering and Architecture Faculty, Department of Energy Systems Engineering, Rize, Turkey
gokcen.akgul@erdogan.edu.tr

Nano sized and conductive carbon allotropes such as graphene and carbon nanotubes, called as technological carbon materials, are very promising materials for flexible, portable, miniaturized, stretchable, lightweight and thin electrical and electronic devices. Their functionality, high charge mobility, thermal stability, certain rigidity and high electrical conductivity make them profited, preferred and trend substances in smart, eco-friendly and sustainable conductive/semiconductive manufacturing processes [1,2].
The technological carbon is synthesized by chemically or expensive processes mostly using the energy sources of fossil fuels which are diminishing and the main reasons for climate change.
Renewable, sustainable, environmentally friendly and clean resources on emerging flexible and soft electronic technologies are desired. Biomass is the only renewable carbon resource which could offer inspiring nano sized carbon allotropes from nature affluently [3].
In this work, graphitic and conductive carbon was derived from industrial tea waste by pyrolysis and electrochemical exfoliation assisted with sonication. Detailed structural characterizations such as TEM, XPS, BET and FTIR were performed. Electrical conductivity was determined by the 4 point method.

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[3] Ouyang, D., Hu, L., Wang, G., Dai, B., Yu, F., Zhang, L., A review of biomass-derived graphene and graphene-like carbons for electrochemical energy storage and conversion. *New Carbon Mater.* 2021, 36, 350–372.

Subject area: Biomass and residue based refineries (green carbon)

Active flue gas condensation with absorption heat pump –experiences, new concepts and potentials

Harald Schrammel, Harald Blazek. Michael Barnick
StepsAhead Energiesysteme GmbH
Meranasse 84, A-8010 Graz
h.schrammel@stepsahead.at
https://stepsahead.at/

Biomass is one of the most important renewable energy sources and according to current energy strategies, its utilisation for heat and electricity production, renewable fuels and material use will be further increasing. To meet these expectations, the available biomass resources must be used with the highest possible efficiency. By combining absorption heat pumps (AHP) with flue gas condensation units for biomass CHP plants, the overall efficiency is significantly increased and up to 40% more energy output is achieved from the same amount of fuel.

Heat recovery with economiser (sensible heat) and flue gas condensation (sensible heat + latent heat of wet flue gas) are installed downstream of biomass boilers to increase the overall plant efficiency. Heat recovery by means of passive flue gas condensation is limited by the return temperature of the heat sink (e.g. heat network). Thus, the heat recovery rate is max. 10-15%. Integrating an AHP leads to an active flue gas condensation system operated at significantly lower temperatures which leads to lower flue gas temperatures and heat recovery rates >30%.

Like conventional heat pumps, AHPs can raise heat from a lower to a higher temperature level. But they are driven by high-temperature heat (typically up to 150°C) and an absorption/desorption cycle using water as refrigerant and a LiBr-water solution as solvent. Hence, instead of expensive electric power the heat produced by the biomass boiler can be used as driving energy to recover otherwise unused low-temperature heat from the flue gas by lifting its temperature. While doing this, the driving heat is not lost, but can still be used together with the recovered heat, for example in a district heating network. This significantly increases the heat output and the overall plant efficiency without additional fuel demand.

Several high-efficiency plants with absorption heat pumps and active flue gas condensation have already been implemented. Operating data of the plants show that flue gas temperatures in the range of 20°C and heat recovery rates up to >40% are achieved. The plants are characterised by very low maintenance costs, very low consumption of operating resource and a long service life.

StepsAhead has developed and implemented a wide variety of technical concepts for single and multiple boiler plants as well as biomass CHP plants. Special attention was paid to individual design, optimal plant integration adapted to the respective conditions and a special control concept for the AHP to maximise the yield in different load conditions. StepsAhead has developed a new system concept in which driving heat of 105°C is sufficient. This can be provided by conventional biomass boilers. Hence, no upgrade or reinvestment costs for high temperature boilers are required and it reduces operation costs since less strict legal requirements apply. This development was made possible by detailed analysis of the internal processes of the AHP and the creation and validation of a detailed physical model of the absorption and desorption process as basis for carrying out comprehensive simulations of the entire plant. This innovative concept allows an easier integration of AHPs into biomass heating plants and is especially interesting for existing or smaller plants. The disadvantage is a lower yield, which is compensated by lower costs for boiler, integration and operation.

High-efficiency biomass CHP plants with AHPs and active flue gas condensation represent the state of the art in technology and efficiency. The systems are proven under real operating conditions and are increasingly implemented in biomass heating plants from approx. 3 MW up to large-scale power plants.

Bioeconomy as a political vehicle for biomass utilization

Dipl.-Ing. Bernhard Kastner
Centre for Bioeconomy
University of Natural Resources and Life Sciences, Vienna
Peter-Jordan-Straße 82, 1190 Wien
bernhard.kastner@boku.ac.at

Dr. Martin Greimel
Centre for Bioeconomy
University of Natural Resources and Life Sciences, Vienna
Peter-Jordan-Straße 82, 1190 Wien
martin.greimel@boku.ac.at

Bioeconomy as a scientific concept was first introduced in the 1970s through an analysis of the economic process with respect to fundamental laws of physics, implying that negative impacts of resource extraction could be reduced by a circular economy with minimized resource throughput. This notion of bioeconomy being closely linked to natural laws never caught up in political economics and was reinterpreted at the beginning of the new millennium by a political agenda for industrial biomass production und conversion in the EU. Following extensive criticism on having missed out on social and ecological sustainability the EU revised their strategy into a sectoral program and inspired countries around the world to develop their own interpretations of a bioeconomy.

With this particular development of the concept, bioeconomy presents a rather unique history: Its origins as a scientific concept progressed into the academic discipline of ecological economics and thereof inspired bottom-up movements within the nature conservation spectrum have however failed to gain a particularly strong influence in political economic discourses within 50 years of its development. Yet the reinterpretation of the term by the European Commission as a high-level top-down strategy has provided proponents of the original meaning with an unparalleled leverage for the implementation of transformative policies.

Through literature review and policy analysis we have identified the intentions of most current bioeconomy strategies to enhance a circular biobased economy, however they differ significantly in the degree in which they either continue to rely on established means of resource extraction or implement alternative ways of material and energetic input into the value-added chain. Additionally, the recognition of the necessary cultural change in particular with respect to consumption patterns is rarely discussed, much less are strategies for promoting such a change implemented.

With this contribution to the conference we would like to highlight those perspectives on and interpretations of bioeconomy which acknowledge the need for or even focus on the development of a more resilient economic system which is operating within the planetary boundaries in a more consistent way with natural processes. We propose that the further science-based development of bioeconomy strategies should lead to a view on bioeconomy not merely as a technical-economical solution for a decarbonized society, but a holistic approach to economy as part of a socio-cultural system integrated into the natural environment from which it draws the most essential resources for survival and propagation. Furthermore, we argue that with the global tailwind of international recognition as a political agenda, the advancement of the bioeconomy as a narrative for a sustainable economic system in strong accordance with the most recent findings in climate and earth system sciences provides a unique opportunity to catalyze the socio-ecological transformation.

Production of Sustainable Activated Carbon – Thermochemical Activation of Gasification Carbon in a Lab-scale Fluidized Bed Reactor

Author: D. Gurtner
Josef Ressel Centre for production of activated carbon from municipal residues, Department for Environmental-, Energy and Process Engineering, Management Center Innsbruck
Universitätsstraße 15, 6020 Innsbruck, Austria
david.gurtner@mci.edu
https://research.mci.edu/de/josef-ressel-zentrum

Co-Authors: M. Kresta, A. Hofmann, C. Pfeifer

The reduction of fossil fuels and the increasing demand of activated carbon (AC) requires a sustainable production of AC from a variety of biogenic materials, including waste. The use of gasification carbon (GC) as precursor for AC meets these framing conditions and additionally achieves negative CO_2 emissions. The porosity of GC is not sufficiently developed for various adsorption applications, which requires thermochemical activation.

In order to maximize the quality and quantity of the produced AC, the optimal activation parameters, i.e. temperature, time and activation medium (CO_2, $H_2O_{(g)}$, Air), have to be determined. Therefore, 7 g GC are activated in a lab-scale fluidized bed reactor at 750 to 850 °C between 5 and 20 min. The mass loss during activation increases with temperature and time. The porosity (specific BET surface area, pore volume), on the other hand, stagnates with CO_2 and even decreases with long activation times if $H_2O_{(g)}$ is used. Nevertheless, $H_2O_{(g)}$ yields at 850 °C and 12.5 min the best results with 795 $m^2 g^{-1}$ and 45 % of micropores. Considering the trade-off between mass loss and developed porosity, optimal activation parameters can be observed – e.g. for CO_2 828 °C and 15 min. Higher specific BET surface areas are achieved with $H_2O_{(g)}$ and larger proportions of micropores with CO_2. By sequential activation, in which $H_2O_{(g)}$ first expands existing pores and subsequently CO_2 forms new micropores, high surface areas (800 $m^2 g^{-1}$) and a high share of micropores (50 %) can be achieved, but also a high mass loss results. The addition of air, which should enable a more economical activation process, results in significantly lower porosity. Nevertheless, the surface area can be more than doubled compared to the GC.

The optimal parameters are to be transferred to an already developed pilot scale activation reactor, which is integrated into a commercial wood gasification plant.

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Understanding the Influence of Extractives on Off-Gassing During Storage of Biofuel Wood Pellets

Workson Siwale [a,d,], Stefan Frodeson [a], Michael Finell [b], Mehrdad Arshadi [b], Carina Jonsson [b], Gunnar Henriksson [c] & Jonas Berghel [a]*

a. *Environmental and Energy Systems, Department of Engineering and Chemical Science, Karlstad University, SE-651 88, Karlstad, Sweden, https://www.kau.se, workson.siwale@kau.se, stefan.frodeson@kau.se, jonas.berghel@kau.se*
b. *Swedish University of Agricultural Sciences, Department of Forest Biomaterials and Technology, SE-90183 Umeå, Sweden, https://www.slu.se, michael.finell@slu.se, mehrdad.arshadi@slu.se, carina.jonsson@slu.se*
c. *Division of Wood Chemistry and Pulp Technology, Department of Fiber and Polymer Technology, Royal Institute of Technology, KTH, SE-100 44, Stockholm, Sweden, https://www.kth.se, ghenrik@kth.se*
d. *Department of Biomaterials Science and Technology, School of Natural Resources, Copperbelt University, P.O Box 21692, Kitwe, Zambia*

**Correspondence: workson.siwale@kau.se; Tel.: +46736770152*

This abstract is submitted to be considered for oral presentation at the 7th Central European Biomass Conference CEBC 2023 under the subject area: Biomass and Residue-based Biorefineries or any other subject area the organising committee may deem appropriate for this presentation. The presentation will be based on the results from the following two published journal articles:

1. W. Siwale, S. Frodeson, J. Berghel, G. Henriksson, M. Finell, M. Arshadi, C. Jonsson, Influence on off-gassing during storage of Scots pine wood pellets produced from sawdust with different extractive contents, Biomass and Bioenergy. 156 (2022) 106325. https://doi.org/10.1016/j.biombioe.2021.106325.
2. W. Siwale, S. Frodeson, M. Finell, M. Arshadi, C. Jonsson, G. Henriksson, J. Berghel, Understanding Off-Gassing of Biofuel Wood Pellets Using Pellets Produced from Pure Microcrystalline Cellulose with Different Additive Oils, Energies. 15 (2022) 2281. https://doi.org/10.3390/en15062281.

Fuel wood pellets have the tendency of internally generating and releasing heat and gasses without external influence, these processes are termed as self-heating and off-gassing. The two processes begin immediately after production and continues during storage. The self-heating and off-gassing of wood pellets therefore, poses a challenge to their transportation and storage. The heat released due to self-heating is a fire risk while off-gassing of toxic gasses such as carbon monoxide and some volatile organic compounds is a human health and environmental hazard. With the increase in production volumes of wood pellets which has subsequently increased the amounts of wood pellets in transportation and storage, there is need to find lasting solutions to off-gassing and self-heating of wood pellets. The objective of this study was to determine the effect of amount and type of extractives on off-gassing of fuel wood pellets. The aim is to come up with raw material pre-treatment measures so as to produce wood pellets that are not liable to self-heating and off-gassing. Scots pine wood pellets produced from sawdust with varying amounts of extractives namely; fresh pine sawdust (FPS), stored pine sawdust (SPS), sawdust plus pine rosin (PRS), sawdust plus linseed oil (LOS), sawdust plus tall oil (TOS) and acetone extracted sawdust (AES) were used to determine the effect of amount of extractives on off-gassing. To assess the effect of type of extractives, pellets produced from synthetic microcrystalline cellulose and different additive oils were used. Pure cellulose was used so as to eliminate the effect of other wood chemical components i.e. hemicelluloses and lignin while the additive oils were intentionally selected to represent different types of wood extractives (mainly fatty and resin acids) and they included: tall oil, pine rosin, linseed oil and coconut oil. The pellets were produced using an Amandus Kahl Model 14-175 (3 KW power rating and 10 - 50 kg/h production capacity) pellet press and thereafter subjected to off-gassing tests under controlled conditions using the ECOM J2KN analyser. The off-gassing results from Scots pine pellets showed that the total amount of extractives in the raw material has little effect on off-gassing, addition of “additional” extractives did not result in increased off-gas emissions, but rather lowered them somewhat. The pure cellulose pellets gave different off-gas concentrations depending on the added additive oil. The highest mean concentrations of the off-gasses; carbon monoxide, carbon dioxide and methane were recorded from pellets with added linseed oil. The formation of methane started later than the carbon oxides and coincided with the time when residual oxygen was depleted. The concentrations of carbon monoxide and methane for the other four pellet types were negligible and there was no carbon dioxide emission. Pellets with added linseed oil had high off-gas emissions due to the high content of unsaturated fatty acids compared to other pellet types.

QM HEIZWERKE UNTERSTÜTZT DIE NACHHALTIGE WÄRMEWENDE

Autoren
Sabrina Metz, Christian Ramerstorfer, Stefan Retschitzegger, Ingo Leusbrock
AEE – Institut für Nachhaltige Technologien
A-8200 Gleisdorf, Feldgasse 19
Tel.: +43-3112 5886 –0
E-Mail: s.metz@aee.at

Einleitung
Seit über 15 Jahren begleitet das Qualitätsmanagementprogramm klima**aktiv** QM Heizwerke verpflichtend geförderte Biomasse-Heizwerke und Nahwärmenetze.
QM Heizwerke wurde eingeführt, da sich zum damaligen Zeitpunkt viele in Österreich bestehende Anlagen in einer Nachhaltigkeitskrise befanden. Durch die QM Heizwerke Qualitätsanforderungen und Richtlinien konnte die Anlagen- und Ressourceneffizienz nachweislich gesteigert und damit technische, ökonomische und ökologische Nachhaltigkeit sichergestellt werden. Die aktuell stark erhöhte Nachfrage nach regionaler und preisstabiler Wärmeversorgung führt wieder zu einem Boom in der Biomassenahwärme. Das beschleunigt einerseits die erneuerbare Wärmewende, erfordert jedoch andererseits mehr denn je die Einhaltung der durch QM Heizwerke definierten Qualitätskriterien, um nicht alte Fehler zu wiederholen und Anlagenerweiterungen langfristig ökonomisch und ökologisch abzusichern.

Strategien und Maßnahmen
Wesentliche Strategie ist die Begleitung eines Nahwärmeprojekts durch erfahrene und ausgebildete Qualitätsbeauftragte (QBs) vom Planungsbeginn bis zum Betrieb und der Optimierung der Anlagen. Die Grundzüge und der Prozessablauf des QM Systems sind in der Schriftenreihe der internationalen Arbeitsgemeinschaft QM Holzheizwerke (ARGE QMH) festgelegt. In Österreich werden die Projekte und die Umsetzung des QM Systems im Rahmen der Förderabwicklung in der QM Datenbank, auf die alle Projektbeteiligten Zugriff haben, erfasst. Darüber hinaus werden auch Betriebsberichte der Anlagen über mehrere Jahre gesammelt. Dieser Datenschatz ermöglicht anonyme Auswertungen, die wichtige Informationen zum aktuellen Stand der Nahwärmeversorgung in Österreich, sowie Inputs zur Weiterentwicklung des QM Systems geben.
QM Heizwerke arbeitet auch an der Verbreitung von Informationen sowie Maßnahmen und Tools zur Unterstützung der Nahwärmebranche und der Wärmewende. Neben Möglichkeiten zur räumlichen Energieplanung als Basis für den nachhaltigen Ausbau und die Verdichtung der Nahwärmeversorgung, wird auch die Nutzung alternativer Wärmequellen und die zukünftige Rolle der Biomasse, beispielsweise in der Industrie, beleuchtet. So wird derzeit an einer Maßnahme zur GIS-Erfassung bestehender Wärmenetze für die Unterstützung der räumlichen Energieplanung gearbeitet. Im Rahmen der durch QM Heizwerke angebotenen Impulsberatung werden ältere Anlagen kostenlos evaluiert und auf ihrem Weg in die Zukunft beraten. Außerdem wird daran gearbeitet, das Erfolgsmodell QM Heizwerke auch international zu verbreiten.

Ergebnisse und Ausblick
Aktuelle Auswertungen der QM Datenbank zeigen stetig messbare Erfolge. Die durchschnittlichen Netzverluste von Nahwärmenetzen sinken bei gleichzeitig steigenden Anschlussdichten und gesteigerter Planungssicherheit. Das QM Planungshandbuch wurde in Zusammenarbeit mit der ARGE QMH vollständig überarbeitet, hinsichtlich der Einbindung alternativer erneuerbarer Wärmequellen erweitert und steht nunmehr kostenlos zur Verfügung. Besonders in Italien konnten große Erfolge zur Internationalisierung erzielt werden. In der Region Friaul Julisch-Venetien gibt es seit 2021 ein neues vollwertiges Mitglied der internationalen ARGE QMH und auch erste durch QM Heizwerke ausgebildete aktive italienische QBs. Die konsequente Umsetzung, der von QM Heizwerke definierten Qualitätsstandards ist notwendig um den langfristigen Erfolg und die Effizienz österreichischer Nahwärmeanlagen auch in Zukunft zu sichern und um das vorhandene Biomassepotential bestmöglich zu nutzen.

Pufferspeicher bei automatisch beschickten Holzfeuerungsanlagen

Lukas Sulzbacher
HBLFA Francisco Josephinum BLT Wieselburg
Rottenhauser Straße 1
3250 Wieselburg, Austria
Lukas.sulzbacher@josephinum.at

Co-Authors: Harald Baumgartner, Josef Rathbauer,

Durch die nationalen Bestrebungen zur Dekarbonisierung der Wärmeversorgung von Gebäuden und dem "Phase-out-Plan“ für fossile Energieträger rücken holzbasierte Heizsysteme in den letzten Jahren wieder verstärkt in das öffentliche Interesse. Auch die jüngsten internationalen Krisen zeigen die Notwendigkeit, die Abhängigkeit fossiler Energieimporte weiter zu verringern sowie die Energieversorgungssicherheit durch eine Nutzung aller ökologisch nachhaltig verfügbaren Biomassepotenziale zu ermöglichen.

Moderne Holz-Zentralheizungen sind mit einer erprobten und hochentwickelten Verbrennungstechnik ausgestattet, die bei entsprechender Brennstoffqualität und Betriebsweise höchste Wirkungsgrade bei sehr geringen Emissionen ermöglichen können. Neben einer adäquaten Brennstoffqualität weisen insbesondere die Betriebsweise und regelungstechnische Maßnahmen zur Optimierung der Verbrennung ein erhebliches Potenzial zur Emissionsminderung an Holzfeuerungen auf. Hierzu kann die Verwendung eines Pufferspeichersystems wesentlich beitragen.

Während Pufferspeichersysteme bei händisch beschickten Scheitholz-Kleinfeuerungsanlagen mit unzureichender Leistungsregelung vorgeschrieben sind, kann die Verwendung auch bei automatisch beschickten Feuerungsanlagen wesentliche Vorteile mit sich bringen.

Im Rahmen von umfangreichen Versuchen am Prüfstand der BLT Wieselburg, wurden die Potentiale zur Emissionsminderung durch den Einsatz eines Pufferspeichers bei automatisch beschickten Heizanlagen untersucht. Viele Feuerungsanlagen sind auf Grund moderner Regelungstechnik sehr gut in der Lage, auf die Änderungen der Leistungsvorgaben zu reagieren, insbesondere bei moderaten Lastwechsel. Sehr geringe Leistungsvorgaben (<20 % der Nennlast) stellen eine Herausforderung für die Regelungen der Feuerungsanlagen dar und Start-Stopp-Betriebszustände mit Gluterhaltung sind die Folge.

Neben den Anforderungen an die Leistungsregelung, haben Lastwechsel auch signifikanten Einfluss auf die Emissionen. Die Erhöhung der CO-Emissionen ist auf die geänderten Brennraumbedingungen im Zuge der Lastwechsel bzw. Start-Stopp-Betriebszustände zurück zu führen. Kurzzeitige ungünstige Verbrennungsbedingungen im Brennraum hemmen die vollständige Oxidation von CO sowie den oxidativen Abbau der Kohlenwasserstoffe. In unterschiedlichen Lastzyklusversuchen konnte gezeigt werden, dass durch den Einsatz eines Pufferspeichers die idealen Verbrennungsbedingungen der Feuerungsanlagen trotz Änderung der Leistungsabnahme verlängert und somit die Emissionen verringert werden können.

Mit der Neuauflage der EN 303-5 im Jahr 2021 hat auch der Pufferspeicher bei der Prüfung von automatisch-beschickten Heizanlagen, die nicht auf 30 % der Nennleistung regelbar sind, Einzug gehalten. Im Rahmen der Versuchsreihen wurden auch die Herausforderungen beleuchtet, die mit der Umsetzung der neuen Norm- bzw. Prüfanforderungen beim Einsatz von Pufferspeichern einhergehen.

Wood-Value-Tool: Techno-economic assessment of the forest-based sector in Austria

*DI Marilene Fuhrmann**
+43 5 02378-9453
marilene.fuhrmann@best-research.eu
Co-Authors:
DI Dr. Christoph Strasser, christoph.strasser@best-research.eu*
DI Dr. Christa Dißauer, christa.dissauer@best-research.eu*
**BEST – Bioenergy and Sustainable Technologies GmbH*
Gewerbepark Haag 3, 3250 Wieselburg-Land, Austria
www.best-research.eu

Background

EU and national policies promote the use of biomass for material and energy purposes to foster a transition towards a sustainable bioeconomy. This transition will rely to a large extent on the advancement in technology of a range of processes, on cost competitiveness, on the achievement of breakthrough in terms of technical performances and will depend on the availability of sustainable biomass. European forest-based industries and wood markets will take a crucial role in this transition, but are confronted with several challenges in tackling the economic, pandemic and climate crises.

Objectives & Approach

A tool for techno-economic assessments based on pre-defined building blocks was developed to provide a basis for taking strategic decisions on whether and how to increase the value added in woody biomass utilization: the "Wood-Value-Tool". This user-friendly Excel-calculation tool, developed within the project BioEcon at BEST – Bioenergy and Sustainable Technologies GmbH, allows to specify selected processes in terms of technical parameters and to select the desired input material.

Results & Outlook

The techno-economic assessment covers the investment, operating and raw material costs, expected product price as well as mass and energy balances. Currently the following processes are included:

- Wood supply
- Pulp production (incl. Lignin and Hemicellulose extraction)
- Paper production
- Regenerated cellulose fiber production
- Sawmill
- Panel production
- Combined heat and power
- District heating plant
- Pellets production
- Wood gasification + BioSNG synthesis
- Wood gasification + FT synthesis
- Flash pyrolysis

TECHNICAL PARAMETERS		
TRL	8-9	
Fuel input	42,8	MW
Efficiency BioSNG	66	%
Total efficiency (incl. heat extraction)	86	%
Operating hours BioSNG	8 000	h/year
Operating hours heat	3 000	h/year
Lifetime of the plant	25	years

ECONOMIC PARAMETERS		
Specific investment costs	2 667	€/kW
Total investment costs	114 147 600	€
Capital cost	6 925 796	€/a
Operating costs:	14 467 898	€/a
Raw materials	9 388 329	€/a
Operating materials	1 141 476	€/a
Disposal costs	228 295	€/a
Power	2 054 657	€/a
Personnel	513 664	€/a
Maintenance	1 141 476	€/a

Figure 1: Excerpt of the Wood-Value-Tool on the example of BioSNG

In a next step, further functions will be integrated in the "Wood-Value-Tool", taking macro- and socio-economic as well as sustainability criteria into account (such as CO_2-equivalent emission calculations). The advanced tool is intended to provide support for sustainable biomass utilization in different industries, based on environmental, economic and social dimensions.

Prospects and challenges for biomass-based gas production in Austria

Authors: Dipl.-Ing. Frank Radosits
radosits@eeg.tuwien.ac.at, +43 1 58801 370367
Associate Prof. Dipl.-Ing. Dr.in techn. Amela Ajanovic
ajanovic@eeg.tuwien.ac.at, +43 1 58801 370364
Ao.Univ.Prof. Univ.Prof. Dipl.-Ing. Dr.techn.Reinhard Haas
haas@eeg.tuwien.ac.at, +43 1 58801 370352
TU Wien, Institute of Energy Systems and Electrical Drives, Energy Economics Group (EEG), Gusshausstraße 25-29/E370-3, A-1040 Vienna

Introduction

Agricultural land is a limited resource and there is already a conflict for the use for food, feed and fuel production and it is likely that this competition will get even stronger (Poore and Nemecek, 2018). This conflict could become worse by increasing biofuel production based on food crops where a negative environmental impact can also become an issue. Therefore, the usage of first-generation biofuels in the share of transport fuels was restricted in the latest directive on renewable energy (Puricelli et al., 2021). In literature, the focus lies mainly on lignocellulosic feedstocks and biowastes. The IEA assessed the global potential of biomethane and bioSNG for feedstocks with no competition to agricultural land and found a great difference between the actual production and the potential.
The economics are still a big obstacle although the environmental prospects are quite promising for example for the usage of bioSNG as transport fuel (D'Adamo et al., 2021). The core objective of this study is to analyze the economic prospects of biomass-based gases by comparing different scenarios for natural gas price developments and the influence of the carbon tax in Austria.

Methods

The natural gas prices were very low before the COVID pandemic and this was a reason against investments in renewable alternatives. However, the prices of all fossil fuels changed significantly in the last two years. Furthermore, the introduction of a carbon tax starting at 30€/ ton CO_2 will lead to price increases for fossil fuels. Three different scenarios were conducted for low, medium and high natural gas prices until 2030 with proposed carbon taxes applied. The production costs of biomethane, bioSNG and natural gas prices of the different scenarios were compared. The production costs were calculated with the levelized cost of energy method (1).

$$c_{fuel} = \frac{CRF * I_0 + C_{OF} + C_{misc}}{FLH} + \frac{P_B}{LHV * \eta} + c_{var} \qquad (1)$$

Results

Biogas plants have usually low capital and operational costs among technologies for green gas production. However, for economic feasibility it is important is to ensure operational safety and high full load hours. Downtimes and technical problems reduce the profitability. The production costs are strongly affected by the chosen feedstock. Biowastes as feedstocks cause lower production costs and also lower environmental impact. Straw can be utilized in different technologies, but the efficiency is lower than for other feedstocks and production costs are high. Assuming that natural gas prices will decrease to pre-COVID prices in the low scenario, with a carbon tax in 2030 of 120 €/ ton CO2 the gas price would still be at least 10 €ct/ kWh. Production costs (2020) for biomethane ranged approximately from 5.5 €ct to 18 €ct/ kWh for selected feedstocks.

Conclusions

Biogas plants fulfill systemic functions and can act as flexible providers for energy in times of high demands. The carbon tax will support the competitiveness of green gases, but with the proposed values until 2030 mainly low-cost feedstocks will probably be feasible without other support schemes.

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The REPLACE Project – Instruments and activities to foster the replacement of fossil heating systems with renewable solutions

Ingo Ball
WIP Renewable Energies
Sylvensteinstr. 2
81369 Muenchen,
Germany
ingo.ball@wip-munich.de

Co-Authors: Dominik Rutz, Herbert Tretter, Karina Knaus, Stefan Drexlmeier, Cornelia Baumann, Heike Unterpertinger, Francisco Puente, Velimir Šegon, Dražen Balić, Fethi Silajdzic, Angel Nikolaev, Gašper Stegnar, Natasa Markovska, Rafael Ayuste Cupido

The heating and cooling (HC) sector comprises 50% of the final European energy consumption. Furthermore, it is responsible for over 68% of all natural gas imports. Permanently reducing energy consumption and increasing the share of renewables in this sector is paramount for a sustainable Energy Union. In particular, the fact that 80 million out of 120 million installed space heating systems in Europe currently achieve an energy label class C or D gives rise to major concern.

In order to meet the climate change target of limiting global warming to 1.5 °C as well as the target of a full decarbonisation by 2050, systems for space heating, which are based on fossil fuels must be phased out as soon as possible. This applies to oil and natural gas boilers, but also to oil and coal ovens, gas heaters, as well as to the supply based on fossil fuels for district heating (DH). Current heating sources need to be substituted in the future by a broad mix of different renewable energy sources, including biomass, solar thermal energy, free energy, geothermal energy, and renewable electricity for heat pumps, but also district heat based on renewable and waste heat or energy sources from cooling. Biomass is the dominant renewable energy source for space heating today and will play also a crucial role in a fully decarbonised space heating scenario in Europe.

The EU H2020 project REPLACE (Contract No. 847087) aims to boost the phase-out of inefficient and old heating and cooling systems by targeting consumers, investors/owners as well as intermediaries (installers, plumbers, and chimney sweepers) and helps them to make independently informed decisions.

All activities proposed by REPLACE aim to inform and motivate consumers to replace their old and inefficient HC appliances with better, greener alternatives with the benefit of monetary savings and improvements in air-quality, comfort, safety, and security of supply. REPLACE also addresses fuel poverty and reduces the risk of a heating crisis by supporting the use of regional renewable energy sources (such as solar, ambient heat or biomass) and equipment produced in the EU (biomass boilers, heat pumps, solar collectors, DH equipment). At CEBC, an overview about the different project activities will be given, and solutions that consider the already known bottlenecks of too few skilled workers will be shown.

Topic: Nachhaltigkeit und Politik: Erreichung der Klimaziele

Ein innovatives Verfahren zur Synthese von Methanol aus Biogas mit hohem Kohlenstoffnutzungsgrad

Autoren
Dr.-Ing. Stephan Anger und Dipl.-Ing. Michael Kühn
stephan.anger@dbi-gruppe.de & michael.kuehn@dbi-gruppe.de Tel. +49 3731 4195 -346 und -326
DBI – Gastechnologisches Institut gGmbH Freiberg Halsbrücker Straße 34 in D-09599 Freiberg
Dr.-Ing. Hans-Peter Schmid hp.schmid@wsreformer.de
WS Reformer GmbH Dornierstraße 14 71272 Renningen Tel. +49 7159 1632 42

Im Beitrag wird ein innovatives thermochemisches Verfahren zur dezentralen Herstellung von grünem Methanol vorgestellt. Bei diesem werden Biogas sowie H_2 und O_2 aus regenerativen Quellen unter nahezu vollständiger Kohlenstoffnutzung zu grünem Methanol umgewandelt. Die Innovationshöhe liegt dabei in einem neuartigen Verfahren zur Herstellung des hierfür not- wendigen Synthesegases, welches mit einer ebenso innovativen Prozessverschaltung die nahezu vollständige Kohlenstoffnutzung für den Gesamtprozess ermöglicht. Basis sind eine Adaption, der aus der Verbrennungstechnologie bekannten FLOX-Technologie (***FL****ameless* ***Ox****idation*) zur Synthesegaserzeugung aus Biogas sowie eine optimierte Energie- und Stoff- stromverschaltung mit der gekoppelten Methanolsynthese. Die Verfahrensentwicklung ist darauf ausgelegt, eine CO_2-neutrale Wertschöpfungskette zu initiieren, deren Kernkonzept es ermöglicht, aus biogenen Reststoffen den chemischen Grundstoff Methanol zu erzeugen. Vorteil gegenüber einer konventionellen Produktion von Biomethan ist die Nutzung beider C-tragender und treibhausgasrelevanter Komponenten CO_2 und CH_4 ohne Separierungsschritt für CO_2. Zudem wird mit Methanol auch ein höherwertiges Produkt erzeugt. Aufgrund der hohen Energiedichte sind grüne flüssige Kraftstoffe für den Schwerlast- und Luftverkehr sowie für agrar- und forstwirtschaftliche Antriebstechnologien von Vorteil. Grünes Methanol kann hier direkt als Kraftstoff oder Basischemikalie zur Erzeugung höherwertiger Kraftstoffe wie Kerosin und Benzin eine wichtige Rolle spielen.

Realisiert wird dies im Rahmen des F&E-Vorhabens SYMBOKO (FKz. 03EE5070A, Laufzeit: 01.08.2021 - 31.07.2023, BMWK, PtJ), wo eine Demonstrationsanlage im Containermaßstab errichtet und im weiteren Verlauf getestet wird, um im ersten Schritt das innovative Verfahren zur Synthesegaserzeugung als Basis zur Methanolsynthese (30 kg/h) abzubilden. Als Ausgangsmaterial für das Biogas kommen fast alle Arten von organischen Abfällen, aber auch Energiepflanzen in Frage, die vorzugsweise in sonnigen und trockenen (ariden) Regionen angebaut werden: Der Feigenkaktus u.a. ist hier eine vielversprechende Option, da er große Mengen CO_2 aus der Luft aufnehmen kann, während das Wasser in der Pflanze verbleibt. Mit entsprechender Substratauswahl ergibt sich somit auch nicht die Herausforderung konkurrierenden Anbaus zwischen Nahrungsmitteln und Energiepflanzen.

Im Beitrag werden der aktuelle Stand der Projektarbeiten sowie die hierfür vorab durchgeführten F&E-Tätigkeiten und Ergebnisse vorgestellt, u.a. das FLOX-Synthesegaskonzept, die Katalysatorentwicklung und -untersuchung sowie die Prozessverschaltung und das Engineering.

Die Teilnahme an der 7. CEBC 2023 wird zusammenfassend als Chance gewertet, unsere Arbeiten zu SYMBOKO einem internationalen Publikum vorzustellen und hieraus internationale F&E-Kooperationen zu initiieren. Primäres Ziel soll hierbei sein, das entsprechende System aus dem Demonstrationsmodus hin zu einer biomassebasierten marktfähigen dezentralen Methanolerzeugungsanlage zu führen.

Fungal pretreated forest residues for production of mesoporous biochar

*Alejandro Grimm and Shaojun Xiong**

Swedish University of Agricultural Sciences, Department of Forest Biomaterials and Technology, 901 83 Umeå, Sweden

Presenter * contact details: Email: Shaojun.Xiong@slu.se, Tel +46-907868778

Abstract:

White-rot fungi such as *Pleurotus* spp. and *Lentinula edodes*, among others, are commonly cultivated on substrates made of hardwood residues and have the ability to use cellulose, hemicellulose and lignin as carbon sources. The total global production of edible mushrooms is approximately 34 Mt with a 30-fold increase since 1978, which corresponds to a value of around 34 billion USD. After cultivation, approximately 70 wt% dry mass of the initial substrate usually remains as a waste known as spent mushroom substrate (SMS). The latter consists of partially degraded cellulose, hemicellulose and lignin, has no commercial value, cannot always be reused within the mushroom production processes, and therefore, represents a problematic waste that needs to be disposed of without generating environmental issues. In this work, *Pleurotus ostreatus* was cultivated on substrates made of birch (*Betula pubescens*) wood. The yield of the first flush of fresh mushroom fruit bodies was 420 g per kg DM substrate. The SMS was employed as a carbon precursor to prepare activated biochars using the chemical activation process with phosphoric acid (H_3PO_4-50wt%) as an activator. The activation process was carried out in a tubular stainless-steel reactor heated externally by an electrical muffle furnace. The impregnation was carried out in one step using a weight ratio of 1 SMS : 3 H_3PO_4, pyrolysis temperatures of 500, 700 and 900 °C, a heating rate of 10 °C/min and a treatment time of 1 h. To study the effect of the degradation of the substrate caused by the fungi on the biochar properties, initial substrate was used as a comparison. It was found that SMS led to higher surface area at lower pyrolysis temperature. The specific surface area (BET) for the SMS based activated biochars was 1325 m^2/g (500 °C), 1223 m^2/g (700 °C), and 1073 m^2/g (900 °C). The BET surfaces areas for the biochars produced from the initial substrate were 1214 m^2/g (500 °C), 1079 m^2/g (700 °C), and 1002 m^2/g (900 °C). A main difference between the SMS and the initial substrate lies in the content of lignin and hemicellulose, 23.26% and 16.07% for SMS vesus 18.29% and 6.51% for the initial substrate. Thermal degradation of lignin and hemicellulose in N_2 atmosphere occurs at temperatures between 320-410 °C and around 290 °C, respectivelly. The differences in the contents of thse two is probably the cause of the differences in the surface areas. Apart from this, The SMS has a structure that is more porous compared to the initial substrate because of the partial decay of cell wall caused by the fungus, and that probably improved the contact and reaction between the activating agent (H_3PO_4) and the precursor and led to higher surface areas.

Keywords: spent mushroom substrate; activated biochar; phosphoric acid activation; adsorbents, surface area.

Improved efficiency and operation of dual fluidized bed gasification plants via model-based control

Thomas NIGITZ[1] thomas.nigitz@best-research.eu
Markus GÖLLES[1,2] markus.goelles@best-research.eu
Christian AICHERNIG[3] c.aichernig@repotec.at
Steffen SCHNEIDER[4] steffen.schneider@ulm-netze.de
Hermann HOFBAUER[1,5] hermann.hofbauer@tuwien.ac.at
Martin HORN[1,2] martin.horn@tugraz.at
1 BEST - Bioenergy and Sustainable Technologies GmbH, Inffeldgasse 21b, 8010 Graz, Austria
2 Institute for Automation and Control, Graz University of Technology, Inffeldgasse 21b, 8010 Graz, A
3 Aichernig Engineering GmbH, Nordbahnstrasse 36/3/Top 2.5, 1020 Vienna, Austria
4 Stadtwerke Ulm/Neu-Ulm Netze GmbH, Kässbohrerstraße 19, 89077 Ulm, Germany
5 Institute for Chemical, Environmental and Bioscience Engineering, University of Technology, Getreidemarkt 9/166, 1060 Vienna, Austria

Introduction

CHP plants based on dual fluidized bed (DFB) gasification can handle low-cost feedstock like wood residues and produce a high-quality product gas as this is nearly free of N_2. The technology is demonstrated in existing plants whose efficiency and operation should be improved. For this reason, the potential for improvement by means of process control was investigated on the basis of the DFB plant in Ulm, Germany (HGA Senden), with 14 MW fuel thermal power.
A DFB plant generates product gas, which at the HGA Senden is utilized in two gas engines for combined heat and power generation. This utilization requires stable product gas properties, but its generation fluctuates inherently. Thus, a surplus of product gas is generated and the fluctuating part of this surplus is burned in an auxiliary boiler. This surplus is automatically set via a PID-controller controlling the pressure at the connection of production and utilization. If this surplus could be reduced, the electrical efficiency should be increased.
Additionally, the average product gas generation at the beginning was manually adjusted via a dosing screw providing fuel. This amount of fuel was decreased manually if too much product gas flows to the auxiliary boiler, or increased if the demand of the gas engines cannot be met. If these manual adjustments could be replaced via a controller, the product gas generation would be smoother and the operating staff would be relieved from this task.

Model-based pressure controller

The aim of this work was to develop a model-based controller that decreases the surplus burned in the auxiliary boiler and that automates the manual adjustments at the dosing screw. For this purpose, this controller uses only the pressure at the connection of production and utilization as its single controlled variable. The model-based pressure controller splits its action on the auxiliary boiler and the dosing screw via separation into fast and slow pressure fluctuations.
This concept was implemented via two PID-controllers in parallel, together providing proper control quality for fast and slow pressure fluctuations. This controller was parameterized and verified in simulation via a mathematical model of the DFB plant. Finally, the controller was implemented in a conventional programmable logic controller (PLC) at HGA Senden.

Results and conclusion

The model-based pressure controller was validated experimentally for one month at the HGA Senden. With this new controller the product gas necessary for the same electricity production by the gas engines was reduced by 5%. This can be related to a reduced fuel consumption of similar value. Additionally, the dosing screw was operated automatically relieving the operating staff from regular manual adjustments. As the developed controller is a pure software update, it can improve the efficiency and operation of existing DFB gasification plants.

Herausforderungen und Lösungsansätze beim Austausch aller Öl- und Gaskessel im Endkundenbereich bis 2045

Volker Lenz[1], Laura García Laverde, Kerstin Wurdinger, Daniela Pomsel, Nora Szarka
[1]Corresponding author: DBFZ Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Torgauer Str. 116, 04347 Leipzig, Germany. E-Mail: volker.lenz@dbfz.de, +49 (0)341 2434-450

Klimaschutz erzwingt den Austausch der Öl- und Gaskessel bis 2045

Rund 80 % des Energieverbrauchs der Haushalte wird für Raumheizung und Warmwasserbereitung (hauptsächlich gedeckt durch Erdgas und Heizöl) verwendet[1]. Klimaneutralität ist nur zu erreichen, wenn alle Öl- und Gaskessel bis spätestens 2045 außer Betrieb gehen oder auf erneuerbare Brennstoffe umgestellt werden. Der Koalitionsvertrag 2021-2025 der neuen deutschen Bundesregierung sieht vor, im Gebäudeenergiegesetz (GEG) zu verankern, dass zum 1. Januar 2025 jede neu eingebaute Heizung auf der Basis von 65 Prozent erneuerbarer Energien betrieben werden soll.[2] Schon jetzt gilt im GEG eine Austauschpflicht für viele Öl- und Gasheizungen, die älter als 30 Jahre sind. Diese müssen gegen eine effizientere Heizungsanlage ausgetauscht werden. Der Einbau von neuen, reinen Ölheizungen ist ab 2026 grundsätzlich verboten es sei denn es ist technisch gesehen keine andere Wärmeerzeugung möglich.[3]

Hemmnisanalyse mit Herausforderungen bei bedarfsgerechter Informationsbereitstellung

Im Projekt OBEN (https://www.dbfz.de/oben-oelersatz-biomasse-heizung), gefördert durch das Bundesministerium für Wirtschaft und Klimaschutz, wurden vielfältige Hemmnisse identifiziert, die Hausbesitzer*innen davon abhalten eine Ölheizung durch eine erneuerbare Heizung zu ersetzen. Darunter sind nicht nur technische Aspekte, sondern auch verhaltensbedingte, kommerzielle und durch fehlende politische Unterstützung bedingte Aspekte. Zu den wichtigsten Hemmnissen gehören die Komplexität der Informationen, die den Hausbesitzer*innen für ihren Entscheidungsprozess zur Verfügung stehen, und der Mangel an objektiven und unabhängigen Berater*innen (Installateurbetriebe, Handwerker*innen, Energieberater*innen). In Verbindung mit der Komplexität der Informationen wird es von den Hausbesitzer*innen als größte Herausforderung empfunden, das geeignete Heizsystem für die Gegebenheiten ihres Hauses und ihre spezifischen Heizanforderungen zu finden.

Fachkräftemangel bei Planung, Angebot, Umsetzung und Wartung

Der Fachkräftemangel ist im Handwerk schon heute ein eklatantes Problem. Dies wird sich durch installationsaufwändigere und komplexere Heizungssysteme nachweislich weiter verschärfen.[4] Da in immer mehr Wirtschaftszweigen fähige und engagierte Arbeitskräfte fehlen, versagen alle bisherigen Lösungsansätze.

Steigende Komplexität durch hybride Lösungen. Während Öl- und Gaskessel einigermaßen überschaubare Technologien darstellen, die in der Handhabung für ihre Eigentümer*innen gewohnt sind, stellen erneuerbare Heizungsoptionen zunächst eine Umstellung dar. Um eine effiziente und sichere Versorgung zu gewährleisten, sind oftmals Kombinationen von erneuerbaren Technologien (z.B. Wärmepumpen-Biomasse-Hybridlösungen) zu empfehlen, die optimal aufeinander und auf die Anforderungen des Gebäudes abgestimmt sein müssen.

Daher sind die nötigen Planungs-, Umbau- und Installationsarbeiten durchaus anspruchsvoll und ohne fachkundige Unterstützung für den Laien kaum zu bewältigen. Auch das Zurechtfinden in der komplexen Förderlandschaft um für den kostenintensiven Austausch die notwendige Förderung zu erhalten, stellt für viele eine große Herausforderung dar.

Zentraler Lösungsansatz Digitalisierung bis hin zur kompletten kombinierten Selbst- und Online-Abwicklung

Im Projekt OBEN hat sich gezeigt, dass der Wechsel von einer Öl- zu einer Biomasseheizung nicht nur von den technischen Herausforderungen der Heizungstechnologie abhängt, sondern weitgehend von den verfügbaren Informationen und den "vertrauenswürdigen" Personen beeinflusst wird, die von den Eigentümer*innen während des Entscheidungsprozesses konsultiert werden. Daher ist es von entscheidender Bedeutung, dass zuverlässige und objektive Informationen im Internet sowie eine klimaorientierte Beratung durch geschulte Heizungsinstallateurbetriebe, Energieberater*innen und anderen zwischengeschalteten Akteuren sichergestellt sind. Als zentralen Lösungsansatz hat das Projektteam daher ein digitales Beratungsinstrument für Eigentümer*innen und Berater*innen identifiziert, das alle wichtigen Informationen und Akteurskontakte rund um den Heizungstausch in einer Anwendung zusammenführt (One-Stop-Lösung) um so den Entscheidungsprozess zu unterstützen, zu vereinfachen und zu beschleunigen. Im ersten Schritt soll Hauseigentümer*innen mittels dieser digitalen Anwendung eine für sie passende und gesellschaftlich erwünschte Heizungsoption vorgeschlagen werden. Mit diesem Vorschlag kann dann auf einen geeigneten Heizungsfachbetrieb zugegangen werden, welcher den gewünschten Vorschlag umsetzen kann und will. Aufgrund des Fachkräftemangels in der Branche wird aber auch angestrebt in Zusammenarbeit mit Partnern aus der Herstellerbranche Technologien anzubieten, die von Laien mit Hilfe einer Bauanleitung selbst aufgebaut werden können.

1 Umweltbundesamt auf Basis Arbeitsgemeinschaft Energiebilanzen: Endenergieverbrauch 2020 nach Sektoren und Energieträgern (Stand 09/2021). https://www.umweltbundesamt.de/daten/energie/energieverbrauch-nach-energietraegern-sektoren#allgemeine-entwicklung-und-einflussfaktoren (Zugriff vom 16.06.2022)

2 Mehr Fortschritt wagen. Bündnis für Freiheit, Gerechtigkeit und Nachhaltigkeit. Koalitionsvertrag 2021-2025 zwischen der SPD, Bündnis90/Die Grünen und der FDP. https://www.spd.de/fileadmin/Dokumente/Koalitionsvertrag/Koalitionsvertrag_2021-2025.pdf (Zugriff vom 16.06.2022)

3 Bundesministeriums der Justiz sowie des Bundesamts für Justiz: Gesetz zur Einsparung von Energie und zur Nutzung erneuerbarer Energien zur Wärme- und Kälteerzeugung in Gebäuden (Gebäudeenergiegesetz - GEG) (Ausfertigung vom 08.08.2020). https://www.gesetze-im-internet.de/geg/GEG.pdf (Zugriff vom 16.06.2022)

4 SHKProfi Online-Portal für das SHK-Handwerk: Fachkräftemangel. Neue Mitarbeiter für sich gewinnen (Stand 09/2019). https://www.shk-profi.de/artikel/shk_Fachkraeftemangel_3473691.html (Zugriff vom 16.06.2022)

Sind Stroh und Mist ein ernstzunehmender Energielieferant?

Josef Höckner Firma BioG GmbH und Ökoenergie Utzenaich GmbH
WEILBOLDEN 18 | 4972 UTZENAICH | ÖSTERREICH
Tel.: 0043 7751 / 50 149, MARKETING@BIOG.AT

Seit vielen Jahren beschäftigen wir uns mit der kaskadischen Nutzung von bisher ungenutzten organischen Reststoffen wie Stroh, Mist und Industrieabfälle. Begonnen hat es 2005 mit unserer Biogasanlage Ökoenergie Utzenaich GmbH mit der wir 2007 aus Kostengründen damit begonnen haben die Einsatzmaterialien von Maissilage auf organische Reststoffe umzustellen welche seit 2015 zu 100% nur mehr mit Reststoffen betrieben wird. Die Nutzung von inhomogenen Abfällen, wie Stroh und Mist, galt bis dahin als sehr schwierig oder als nicht machbar da die technische und biologische Erfahrung fehlte. Aus diesem Grund entstand 2008 die Tochterfirma BioG GmbH, angefangen von der Ernte, Materialtransport, Lagerung, Dosierung, Aufbereitung bis zur Anlagenbiologie hat sich BioG um sämtliche kritischen Schnittstellen die bei der Reststoffnutzung auftauchen angenommen und gelöst. Mittlerweile durften wir bereits über 300 Projekte weltweit bei der Umstellung auf Reststoffe begleiten und so auch eine Menge Erfahrung mit den verschiedensten Materialien sammeln.

CO_2 Reduktionsziele und steigende Energiepreise machen alternative Formen zur Energiegewinnung und somit auch die Biomethanproduktion aus organischen Reststoffen attraktiver als je zuvor.
Gerade auch für landwirtschaftliche Betriebe bietet die Verwertung von Feldresten für die Energieproduktion ökologische als auch ökonomische Vorteile und Chancen.
Wir haben es uns zur Aufgabe gemacht, Ressourcen vor Ort zu erkennt und nutzbar zu machen, anstatt sie am Feld verfaulen zu lassen und sich von anderen Ländern energetisch abhängig zu machen. Das schafft nicht nur eine beachtliche Energiemenge und Treibhausgasreduktion sondern auch regionale Ressourcenwandlungsprozesse und somit Wirtschaftsleistung und Arbeitsplätze in der Region.

Aber

- wie aufwendig ist es diese Reststoffe in eine nutzbare Energieform umzuwandeln
- Welches Energie- und Treibhausgas Einsparungspotential liegt in diesen Materialien.
- Welche Energiemengen verschlingt das „Verfügbar machen“ dieser Reststoffe (Ernte, Aufbereitung usw.)
- Welches Energiepotential liegt noch in diesen Reststoffen
- Welche biologischen Probleme kommen auf mich zu
- Wie und in welcher Form passt Biomethan in den erneuerbaren Energiemix
- Ist ein „echtes“ unabhängiges regionales energieautarkes Energiekonzept möglich

Differences in biochar properties derived from organic residues like unused remains from herb production

Authors:
Konstantin Moser, MSc
BEST GmbH, Gewerbepark Haag 3, 3250 Wieselburg-Land
+43 5 02378-9456, konstantin.moser@best-research.eu
DI Dr. Elisabeth Wopienka
BEST GmbH, Gewerbepark Haag 3, 3250 Wieselburg-Land
+43 5 02378-9438, elisabeth.wopienka@best-research.eu
Univ.Prof. Dipl.-Ing. Dr.techn. Christoph Pfeifer
Institut für Verfahrens- und Energietechnik (IVET) – Boku Wien
Muthgasse 107/I, 1190 Wien
+43 1 47654-89301, christoph.pfeifer@boku.ac.at

As concerns for climatic changes and environmental impact of human behavior grew over the past decades, recycling technologies became more and more attractive. For organic residues, a promising way of recycling is its thermochemical conversion to burnable gases, biochar and - oil through pyrolysis, because the valorization of biomass residuals and their conversion to green carbon and renewable energy describe an important step in the direction to a circular economy. While the gases and vapors are mainly interesting for energetic uses, the produced char offers a lot more versatility in usage, like e.g. agricultural applications or its employment as an adsorbent for various applications. Albeit nearly every biomass could be an interesting resource for biochar production, one particularly important type of biomass are agricultural residues, due to the sheer amount that is produced annually and the usually low usability. As of now, biochars from herb residuals and agricultural remains are not completely unknown materials and there exists literature on various different feedstocks. However, there is still a lack of research on how process conditions influence the biochar properties of different input materials or interactions when processing raw material mixtures. Thus, the aim of this work was to pyrolyze various different residuals from agriculture and herb production (e.g. mary thistle or chive residues) and compare the produced biochars to get a deeper insight in conversion properties of different raw materials as well as suitable fields of application of the particular biochar produced. The different feedstocks were pyrolyzed with lab-scale equipment (e.g. muffle oven and a single particle reactor), either purely or mixed in defined ratios. Different temperatures were investigated and the developing gases were analyzed. Char samples were characterized by physico-chemical analysis, like elemental analysis, calorimetry and pH measurements. Results in terms of e.g. elemental composition, heating value, nutrient availability or porosity are compared and impact of conversion conditions as well as input material properties are identified. The results serve to improve the general understanding of biochars from agricultural residues and the effect of co-processing different feedstocks in pyrolysis, while also providing useful data on the properties of certain herbal and other agricultural residues.

The abstract is related to the topic:
Biomass and waste material based biorefineries / Biomasse und reststoffbasierte Bioraffinerien

Priorität 1 für die Urbane Raumwärmewende: Grüne Fernwärme flächendeckend „as a service“ Strategieimpulse aus Forschung und Markt

Dr. Wolfgang Horn, Geschäftsführer, wolfgang_horn@drei.at, Horn Consult, Grazer Gasse 4, A-8430 Leibnitz

Der österreichische Klima- und Energiefonds (KLIEN) fokussiert im Rahmen der „Vorzeigeregionen Energie“ Zukunftslösungen in Kombination realer Demonstratoren mit der Forschung. Hier werden aus dem Leitprojekt „Thermaflex“ des Green Energy Labs die vom Autor bearbeiteten strategischen Impulse zusammengefasst und in der Vortragsfassung in 9 Charts / 11 Minuten vorgestellt. Das Modell wurde Ende 2020 erstmals publiziert und ist durch die Energiekrise 2022 stark aufgewertet worden.

Städte mit Fernwärme haben eine besondere Rolle in dieser weitreichenden Herausforderung für beispielhafte Realisierungen bei der Wärmewende. Der Wärmemarkt ist, wenn er nicht-fossil dargestellt werden soll, als lokale bzw. regionale Kreislaufwirtschaft realisierbar und somit wesentlich unabhängiger von (globalen) Börsenpreisen. Das ist, neben Klimazielen, in Hinblick auf die disruptiven Marktveränderungen und Neubewertungen wie der wirtschaftlichen Landesverteidigung (Gegengewicht zur Gas-Erpressbarkeit) und Versorgungssicherheit im Jahr 2022 von entscheidender Bedeutung.

Ausgangspunkt war das im STRATEGO-Projekts festgestellte Ergebnis mit Skalierungsanspruch auf alle EU-Städte: „Es wurde gezeigt, daß es in dicht besiedelten Gebieten in Hinblick auf Energieeffizienz, Wirtschaftlichkeit und CO2-Emissionen auf lange Sicht (Perspektive 2050) am sinnvollsten ist, die Wärmeversorgung fast ausschließlich auf Fernwärme aufzubauen".

Diese Prämisse wurde im Strategiefindungsprozess des „Thermaflex“-Projekts validiert und für den Rollout in der Vorzeigeregion Österreich extrapoliert. Neben den Demonstratoren war insbesondere der Erkenntnisgewinn aus der Energieraumordnung, die Ereignisse der (Energie-) Märkte 2010-22 und Statements der Stakeholder wichtiger Input für die diese Arbeit.

Das Postulat „Priorität 1 = grüne Fernwärme“ ist eine Bottom up Strategie der Städte, die Regulative und Rahmenbedingungen auf flächendeckende Fernwärme in dicht verbauten Zonen verbindlich auszurichten. Dieser Ansatz ergänzt Top-down-Ansätze der nationalen Impulse wie zB das EWG.

Konsequent dem folgend werden für den städtischen Raum keine Einzellösungen mehr zugelassen, sondern eine Lösung mit „shared infrastructure“ präferiert. Das ist aus Smart City Perspektive nur folgerichtig und wird am Beispiel Abwasserinfrastruktur und deren Entwicklung im 20. Jahrhundert demonstriert. „Grüne Wärme as a service“ ist wie Abwasserentsorgung ein „Smart City must have“, das flächendeckend real und voll digitalisiert auszuführen ist im dichten Stadtgebiet. Nach derzeitigem Forschungsstand sind damit um die 66-70% aller Einwohnerinnen in Österreich zwischen 2030 und 2040 mit „Grüner Wärme as a service“ krisensicher zu versorgen und zugleich vollständig in real time Daten gestützt erfasst. Die Nachfrageseite ist so fixiert.

Details und technische Perspektive liefert das „Thermaflex-Modell“ dazu, auch als „Drehscheibe Fernwärme“ bezeichnet (AEE-Intec). Die Dekarbonisierung bestehender, noch nicht (ganz) „grüner“ Fernwärmeanlagen ist dabei selbstverständlich integrierter Task von höchster Bedeutung. Der Task wird aber erst durch die Prämisse der Maximierung der Nachfrageseite „geboostert“.

Wirtschaftstheoretisch gesprochen transformieren wir so den bisher Angebot-orientierten Ansatz (push) in einen Nachfrage-orientierten Ansatz (pull). Die Nachfrageseite wird verbindliche Größe und so die Raumwärmewende erstmals quantifizierbar, kalkulierbar, skalierbar, planungssicher und kommunizierbar. Erst solche klaren, eindeutigen Rahmenbedingungen in einer Stadt schaffen Sicherheit und sind belebend für starke Investments in eine flächendeckende neue Post-carbon Infrastruktur, Green Jobs und Klimaschutz. Geschäftsmodelle der kommenden, für Versorgungssicherheit wie für Klimaschutz entscheidenden Jahre, können und müssen auf dieser strategischen Basis erst(mals) zu Ende formuliert werden.

Biomasse ist in diesem Modell die herausragende Ressource zum Betrieb der grünen Fernwärme. Das Know-How der gesamten Lieferkette, technischen Verarbeitung und Optimierung wurde in Österreich über Jahrzehnte gewonnen und erweitert. Sicherheitspolitisch, ie die Energieversorgungssicherheit betreffend, hat Österreich damit einen Unique Selling Point. Wenngleich auch andere Wärmequellen wie thermische Solarenergie, Abwärme, Geothermie und Biogas von (steigender) Bedeutung sind, ist Biomasse DIE Basis für moderne urbane Fernwärme. Die mit diesem Modell angewandte Methodik ermöglicht so für den Biomasse-Sektor eine Kalkulierbarkeit und Sicherheit für eine massive Steigerung der Umsätze – genau das fehlte in den vergangenen Jahrzehnten.

Pyrolysis technology for waste biomass conversion

Václav Marek[1]
[1]*University of West Bohemia in Pilsen, Regional Technological Institute, 30100 Pilsen, Czech Republic*

Modern production of energy in central Europe deals with many threats and uncertainties. Production and processing biomass into energy is one of a few possible ways how to ensure stable source of relatively pure and reliable energy. Conversion of biomass into fuels, heat, or electricity depends on many factors which define useful conversion technology.

Presented technology is based on indirect heating of processed materials. Gas conversion of woodchips suitable for condensation into fuel deals with different quality of input material. Quality evaluation should handle with humidity, wood kind or unsuitable content. Commonly used gasification or pyrolysis is negatively affected by these contents. Developed technology uses external regulated source of heat energy which is not affected by quality of feedstock. Direct combustion of processed material significantly changes properties of output gases and liquids. It is characterised by high amount of nitrogen oxides and carbon dioxide in gases. These technologies also deal with char content in potential liquid fuels. High quality products are characteristic for new pyrolysis technology, which is scaled for industrial purposes. Energetic potential of output products can be used as a necessary input source and also to produce liquid fuels.

Technology consists of input airtight material feed system, rotating reactor which can reach up to 800°C and condensation unit. The reactor chamber is able to process 400kg of material per hour in temperature above 750°C. These temperature regimes are suitable for processing of wooden biomass. Pilot prototype plant was tested by lower temperatures around 500°C which is suitable for polymer waste pyrolysis. This technological property targets on the current deep problem with waste management over the world. Pilot tests were performed with chopped tires. Condensation unit consists of special spray condenser. Emitted gas is mechanically cleared and sprayed by condensation medium. Required content of gas is supported by added catalysts. Fluid products are separated by density fractions. Modification for wooden waste material consists of common condenser with heat exchanging steel interface. High content of water cannot be condensate in spray device and mixed with medium.

Development of a new technology is expansive task, in general. Material inputs and delivery of sub-devices are demanding in present days. Material save, predictions of parameters and overall simulations known as a digital twin are goals for advanced simulation methods. The heat transfer simulations of the chopped material in rotated drum oven is not a trivial issue. The heat-transfer and the mass flow is commonly described by coefficients and predicted dependencies. Heat transfer into moving particles is difficult phenomena. Condensation of output gas mixtures is very specific issue with many unknown parameters. Presented simulation case studies were performed during the development. An accuracy of results is influenced mostly by the defined boundary condition. The definition of boundary conditions is a significant problem of non-homogeneous materials, natural materials, sawdust, etc. Due to that, the verification and the validation of simulations is necessary. Prototype measurements of prototype provided vital data. The measurements provide data about heat transfers, thermal capacities and internal reactions. The post-processing of measurements combined with CFD/FEM simulations provides data about hidden inner heat transfers, reactions and structural behaviour.

This research paper reviews goals of the pyrolysis technology development with emphasis on used calculations and simulations. Computations are described and partial problems of simulations are solved. The results of measurements and technology tests are presented. It provides a real description of the technology.

Keywords: waste material, pyrolysis, computed fluid dynamic, final element method, heat transfer

Heat-to-Fuel: Techno-economic performance of an industrial scale plant for the conversion of wet and dry organic residues into biocrude and FT-products

Authors:

Richard ZWEILER[1] *DI Dr. Tel.: +43 3322 42606 311, e-mail: r.zweiler@get.ac.at*

Katharina Kreuter[1] *DI, Tel.: +43 3322 42606 333, e-mail: k-kreuter@get.ac.at*

Rok Sunko[2] *Tel.: +386 31323853, e-mail: rok@skupina-fabrika.com*

Blaž Sunko[2] *Tel.: +386 41971738, e-mail: blaz@skupina-fabrika.com*

[1] *Güssing Energy Technologies GmbH (ACR), Wiener Straße 49, 7540 Güssing*

[2] *Skupina Fabrika d.o.o., Slovenia - 9240 Ljutomer, Radomerje 14L*

Abstract:

Within the H2020 RIA “Heat-to-fuel” a highly integrated process has been developed, which is in the the position to convert a wide range of biogenic residues into FT-products and biocrude. Two routes are coupled via heat and mass integration. One is the dry route, where for example straw/bark mixtures are gasified, the syngas is then converted via a millistructured reactor into FT-products. The other one is the wet route, where feedstocks as lignin are converted, and consists of a HTL unit, as well as of a downstream APR unit, where the aqueous phase is processed. The heat of the endothermic dry route is fully integrated into the wet route, the hydrogen produced by the APR-unit is fully integrated into the dry route. The TRL has been raised to 5 and a successful whole-chain demonstration carried out in Wien-Simmering.

The performance of the process has been validated by three different process simulations in IPSE-pro, Aspen and finally implemented into a techno-economic assessment tool in Excel. With the results of all experimental series the performance of an industrial scale plant has been designed. For such a plant detailed OPEX have been estimated and CAPEX have been determined according to the capacity factored method. An extensive parameter variation for all surrounding conditions have been conducted, which lead to two final business cases in Estonia and Belgium. 8 different scenarios have been computed taking into account three different main parameters: i) biomass, resp. biogenic residues, ii) fuel input power 50 MW each for the dry and wet route as well as 100 MW, iii) operation with internal hydrogen resource as well as injection of additional hydrogen. CAPEX of these plants varies between 131 to 336 M€, the internal rate of return is between 9,4 to 33,4%, the payback periods start at 3,9 years and is more than 20 years in the least competitive scenario. The levelized costs of fuel are between 77,6 and 107,2 €/MWh. In the case of additional hydrogen injection the total carbon conversion is 53,5%.

The Solid Biofuel Market in Austria – historical development and outlook

Authors: DI Dr. Christa Dißauer, DI Dr. Monika Enigl, DI Dr. Christoph Strasser (BEST – Bioenergy and Sustainable Technologies GmbH
BEST – Bioenergy and Sustainable Technologies GmbH
Gewerbepark Haag 3, 3250 Wieselburg-Land, Austria
christa.dissauer@bioenergy2020.eu
www.best-research.eu

Historic market development[1]

The energetic utilization of biomass has a long tradition in Austria and is still a very important factor within the renewable energy sector. The consumption of final energy from solid biofuels increased from 142 PJ in 2007 to 204.89 PJ in 2021 (Figure 1). The main application of bioenergy is in renewable heat, both in direct heating (residential, services and industry) and in district heating. Solid biofuels represent the major part (>80%) of bioenergy in Austria. They include wood logs, wood chips, wood pellets, bark, and sawmill by-products, of these wood chips and wood logs are the main biomass fuel used in Austria. The consumption of wood chips has been increasing since the beginning of the 1980s. In 2021 the wood chips consumption reached 95.2 PJ and thus exceeded the consumption of wood logs with 79.6 PJ. Main factors influencing the annual bioenergy consumption are the weather conditions and the number of installed biomass boilers. Fuels from solid biomass contributed to a CO_2 reduction of about 10.19 million tons in 2021. The whole sector of solid biofuels made a total turnover of 1.567 billion Euros thus creating 17,932 jobs.

Outlook

The success of bioenergy mainly depends on the availability of suitable biomasses in sufficient volumes and qualities at competitive prices. Subsidies for biomass heating systems, the current crisis in Ukraine and the associated political measures, such as accelerating the phase-out of natural gas for heating purposes, are likely to keep demand for solid biofuels high. In the long term, the demand for solid biofuels in the residential heating sector will drop due to the thermal improvement of the building stock, the switch to electricity-based heating systems (e.g. heat pumps) and climate change and the associated reduction in heating degree days. The importance of bioenergy as part of a sustainable energy system in combination with other renewables will increase as biomass fuels are weather-independent energy suppliers. There is potential to use biomass to provide high temperature heat for industry processes. Depending on the respective application and its requirements different conversion paths, e.g. greening the gas, or intermediate steps, e.g. secondary energy carriers, can be chosen. Regarding the efficient use of resources, the co-production of electricity and/or material products such as biochar are of great interest. Regarding the mobility sector, in addition to the "classic" biofuels, synthetic fuels made from biomass (e.g. Fischer Tropsch fuels made from solid biomass) represent interesting alternatives for different applications. These range from "green diesel and petrol" to aviation fuels ("jet fuel"). The major challenges of decarbonizing mobility in the areas of off-road, heavy and air traffic suggest an increased use of biofuels in these areas.

[1] P. Biermayr, C. Dißauer, M. Eberl, M. Enigl, H. Fechner, B. Fürnsinn, M. Jaksch-Fliegenschnee, K. Leonhartsberger, S. Moidl, E. Prem, C. Schmidl, C. Strasser, W. Weiss, M. Wittmann, P. Wonisch, E. Wopienka: "Innovative Energy Technologies in Austria: Market Development -Biomass, Photovoltaic, Solarthermal collectors, Heat pumps and Wind power", annual market study published by BMK (former BMVIT)

DAS „KLIMAAKTIV SORGLOS KESSELTAUSCH“ PILOTVORHABEN IM LAND SALZBURG – ERSTMALS MIT „ALL-IN SERVICES“ FÜR KLIMAFREUNDLICHES HEIZEN EINFACH UND RASCH UNABHÄNGIG VON ÖL UND GAS WERDEN

Herber Tretter[1], Karina Knaus[1], Altan Sahin[1], Kerstin Schilcher[1], Elisabeth Matt[1]

[1] Österreichische Energieagentur, Mariahilferstraße 136, 1150 Wien, www.energyagency.at.
herbert.tretter@energygency.at

Projekt-Hintergrund und Ziele

Von der Österreichischen Energieagentur wurde innerhalb des EU Projekts REPLACE gemeinsam mit dem Klimaschutzministerium (BMK) und dem Referat Energiewirtschaft und -beratung (20404) des Landes Salzburg ein Webportal zur Vermittlung von standardisierten "klima**aktiv** Sorglos Kesseltausch" Angeboten ins Leben gerufen. Es handelt sich dabei um ein Pilotvorhaben, bei dem unabhängige Stellen eine Vermittlungsplattform für „klima**aktiv** Sorglos Kesseltäusche“ entwickelt haben, die von teilnahmeberechtigten Akteur:innen des Heizungsmarktes (z.B. Installateurs-, Heizungsanlagenbau-, Großhandels-, Energie-Service-Betriebe etc.) für Haushalte angeboten werden. Im Erfolgsfall können Pilotplattformen in bis zu vier Bundesländern bis ins Jahr 2026 bestehen, um Erfahrungen zu sammeln.

Ziel des von der EU im Rahmen des Horizon-2020-Programms geförderten Projekts ist es, Menschen in neun unterschiedlichen Staaten zu motivieren und dabei zu unterstützen, ihre alten, ineffizienten Heizungsanlagen durch saubere, klimafreundliche, komfortable und zukunftsfitte Anlagen zu ersetzen.

Die „Sorglos Kesseltausch“-Initiative will den Austausch von Öl- und Gaskesseln sowie Allesbrennern für Haushalte deutlich einfacher machen, in dem alle Gewerke vor Ort, an der Baustelle durch eine Ansprechperson koordiniert und überwacht werden. Gute und nachhaltige Lösungen sollen durch eine vorausgehende, unabhängige und kostenlose Energieberatungen und durch standardisierte Sorglos-Kesseltausch-Angebote (All-in Paket-Service(s)) für Haushalte rasch und einfach realisierbar werden.

Mit wesentlichen Heizungsmarkt-Akteur:innen wurden bedarfsgerechte Maßnahmen entwickelt

Das Projekt REPLACE brachte 2020 bis 2021 erstmalig (über)regionale Installateurs-, Anlagenbau-, Großhandels-, Energie-Service-Betriebe, Interessensvertretungen und die öffentliche Verwaltung in einer lokalen Arbeitsgruppe zusammen an einen Tisch. In der österreichischen Zielregion, dem Bundesland Salzburg konzentriert sich das Projekt auf den Ausstieg aus allen Öl- und Gas-Heizungen und alten Allesbrennern hin zu sauberen Lösungen. Mit Start im Land Salzburg wurde das Pilotvorhaben "klima**aktiv** Sorglos Kesseltausch" entwickelt. Über eine Webplattform werden Haushalten sorglos All-in Kesseltausch Pakete angeboten. Das von allen teilnahmeberechtigten Sorglos Heizungstausch Anbieter:innen **verpflichtend** anzubietende **All-in Paket-Service** (**Basispaket**) garantiert mit seinem Ablauf und Umsetzung, dass **der Heizungstausch in hoher Qualität, rasch und effizient** erfolgt.

Bündelung von Umsetzungskompetenz im Form eines One-Stop-Shops zum Kesseltausch.

Passende Lösungen werden durch eine kostenlose, **unabhängige Energieberatung** identifiziert. Die Sorglos Kesseltausch Vermittlungsplattform ermöglicht allen Haushalten eine schnelle, unkomplizierte Einholung vergleichbarer Angebote. Die **Umsetzung** des Kesseltausches wird vom gewählten Heizungstausch-Profi **gewerkeübergreifend** über eine **zentrale Ansprechperson** für den Haushalt **koordiniert und überwacht**. Diese zentrale Ansprechperson (z. B. der:die ausführende Installateur:in) **organisiert alles was vereinbart ist** und **unterstützt den Haushalt bei allen Fragestellungen** rund um bestellte „All-in-Paket-Services“ (egal ob Basispaket oder auch bestellte weitere Dienstleistungen), bei Förderungen et cetera. Das neue Angebot wird von den Beteiligten und durch REPLACE bei vor Ort Informationsabenden mit Unterstützung der Manager:innen von Klima- und Energieregionen und e5-Gemeinden ab Herbst 2022 beworben. Alle Sorglos Anbieter:innen erfüllen die Teilnahmebedingungen.

Energy Model for Continous Single-Pellet Presses

Stefan Frodeson[*] [1], Jonas Berghel [1] & Magnus Ståhl [1]

[1] Environmental and Energy Systems, Department of Engineering and Chemical Science, Karlstad University, Karlstad SE-651 88, Sweden; Jonas.Berghel@kau.se; Magnus.Stahl@kau.se

** Correspondence: Stefan.Frodeson@kau.se*

Introduction

Increased costs for fossil based energy resources and developing countries replacing charcoal with pellets in advanced cook stoves are two major driving forces for an unheard of increased demand for pellets worldwide. Pellets are an uniform, dry and compact transportation package and fuel that could be used for heating, electricity production, and advanced biomass cooking. To fully understand the pelletizing process research is required, and New Development for Pellet Technology at Karlstad university, Sweden, is doing basic and applied research in three scales. The smallest, Single-pellet presses (SPP), are predominant in research facilities, universities and institutes, worldwide. Small quantities of materials, can be tested and quick results on optimal moisture content, binding characteristics, possible raw material mixes and more can be presented. However, few of these SPP-units are continous, making it somewhat difficult to scale up the findings to industrial production. Therefore, an energy model for an continous SPP-unit has been developt to distingquise between the three different sources of work taking place within the industrial die, i.e., *Compression work*, *Flow work* and *Friction work*.

Materials and Method

Two Scots pine (*Pinus sylvestris*) wood species, juveline and mature, were used as raw materials, and pelletized at moisture contents of 6, 8, 10, 12 and 14% (wb) in a semi continuous SPP-unit that enables production of pellets at different die presslengths. In this study, a die with 20 mm presslenght and a press ratio of 2.4 was used. The cone of the entrance hole has a diameter of 10.2 mm and a depth of 3.1 mm. 0.25 g of sawdust per occasion was pressed at a time with the speed of 10 mm/min, and when the process was under constant conditions, sample data were taken from 6 different densification processes. During densification, the force, speed, position and time was logged five times per second. The total energy was calculated by integrating the force and distance from the logged data by using the numerical integration trapezoid method, depicted as W_{tot} (J/g). The total energy is the sum of the energy for compression, flow and friction. The compression energy, depicted as W_{comp} (J/g), is determined from 0.2 kN up to F_{max} or the point where the speed started to accelerate. The energy for friction, depicted as W_{fric} (J/g), is determined by pressing the pellet a distance of 3 mm in the die. The flow energy, depicted as W_{flow} (J/g), was assumed to be the remaining energy from the total energy, $W_{flow} = W_{tot} – W_{fric} – W_{comp}$.

Results

The results show that the total energy to pelltize the materials decreases as the moisture content increases. For mature wood from 161 to 93 J/g and for juvenile wood from 180 to 76 J/g, which was expected. For both materials, the proportion of W_{comp} is not affected by increased moisture content. For W_{fric}, the proportion increases with increased moisture content at the expense of W_{flow}, see Figure 1. An explanation for the relative decrease in W_{flow} is that with increasing moisture content, the material's flexibility increases and then mainly compression occurs in the radial direction. Further research will show if the the energy model presented can be used for the upscaling of results from SPP to industrial pellet production.

Support for Energy Communities in Europe

Dominik Rutz
WIP Renewable Energies
Sylvensteinstr. 2
D-81369 Muenchen
Germany
dominik.rutz@wip-munich.de
www.wip-munich.de
https://shares-project.eu

Co-Authors: Rita Mergner, Dominik Rutz, Angela Holzmann, Kerstin Schilcher, Altan Sahin, Natascha Fenz, Ulfert Höhne, Angel Nikolaev, Mariya Trifonova, Thekla Heinel, Avigdor Burmeister, Benjamin Dannemann, Eszter Süle, Nikoloz Sumbadze, Slavica Robić, Tijana Simek, Bence Kovács, Bea Lugosi

Energy communities bear the great potential to enable European citizens to produce, consume, store and sell their own energy. They are member-based organisations whose primary purpose is to provide environmental, social and economic benefits to community members or to the local areas in which they operate. A key aspect of energy communities is the collective ownership and management of the respective facilities. Since the main purpose of an energy community is to generate benefits for the community, energy communities usually reinvest a large part or all of the profit in their operations before distributing any kind of dividend to their members. Today, there are an estimated 3,500 energy cooperatives in Europe, representing over one million EU citizens. Only a minority of them can be found in Eastern Europe because of several factors, including financial constraints, unsupportive legal frameworks and non liberalised energy markets .

The Clean Energy for all Europeans package paves the way for an energy revolution by putting the consumer in the driving seat of the green transition process. Energy communities offer the unique opportunity for consumers to form critical mass and become renewable energy producers and offer their demand flexibility to the market. However, the current requirements of becoming a prosumer bear a crucial risk that ultimately there will be a two-speed energy world: those who have the knowledge, access and opportunity to become a prosumer, and those who lack the resources, know-how, education or time to participate in and benefit from the new opportunities. Therefore, there is a clear need to support local heroes (i.e. those interested in setting up collective actions) in establishing their energy community and enable them to motivate and target consumers directly. This is particularly important for countries where energy communities are yet to be established.

The EU funded project SHAREs (Horizon 2020, Project number 101033722) supports the set-up of new energy communities as well as other collective actions and helps existing energy communities to grow on a large scale. It aims to equip local heroes – organisations, public authorities or individuals who push the initiation of energy communities – with a country-specific implementation toolkit and a communication campaign that allows them to launch and expand a large variety of collective actions in a simple and smart way.

A presentation at the CEBC will provide an overview on the SHARES project as well as on energy communities in Europe. A specific focus will be on the important role of bioenergy for energy communities.

European Technology and Innovation Platform on Renewable Heating and Cooling

Renewable Heating and Cooling in Europe: innovation, support, and policy development

Dominik Rutz[1], WIP Renewable Energies, dominik.rutz@wip-munich.de
Andrej Misech[2], The Association of European Renewable Energy Research Centers (EUREC), misech@eurec.be

Each year, almost 50% of the final energy consumed in Europe is used for heating, cooling or refrigeration either for residential, tertiary or industrial purposes. The vast majority (around 75%) of this energy demand is met by the combustion of fossil fuels such as oil, gas and coal – which do considerable environmental damage, including in terms of greenhouse gas emissions and air pollution – while only 19% is generated from renewable energy. Today the social, environmental and economic costs of climate change make the mission of embracing more sustainable sources of energy urgent. Decarbonising the heating and cooling sector will be key to achieve the European Green Deal goals and making Europe a climate-neutral economy by 2050. The recast of the Renewable Energy Directive increases the current EU-level target of "at least 32 % of renewable energy sources in the overall energy to at least 40 % by 2030". Specific targets are proposed for renewable energy use in heating and cooling, among other sectors. To meet both our climate and environmental goals, the momentum for deploying renewable H&C (RHC) technologies has never been stronger. Finally, the energy transition in the heating and cooling sector is of high importance to gain energy independence and to increase security of energy supply. Although this aspect was always important, it gained top priority in these days due to the current war in Ukraine and the related impacts on energy imports to Europe.

Recognising this situation, the European Technology and Innovation Platform on Renewable Heating and Cooling (RHC-ETIP), aims at playing a decisive role in protecting Europe's leading position in renewable heating and cooling technology. We want society to benefit from an increased contribution of renewable heating and cooling, which will help to reach the vital goal of a carbon-neutral world by mid-century.

The RHC-ETIP is a forum where European industry and research stakeholders can define technological research needs and set strategic priorities to increase the use of renewable energy sources for heating and cooling. RHC-ETIP employs mixed structure, utilising five technology panels (i.e. solar thermal, biomass, geothermal, heat pump, district heating and cooling & thermal storage), as well as four Horizontal Working Groups (HWGs) (i.e. buildings, districts, cities, industries), which bring together interested experts from different technologies directly related to heating and cooling from renewables to think synergistically about how to tackle some high-level challenges. The RHC-ETIP takes a holistic view of research and innovation priorities related to renewable heating and cooling technologies, providing strategic insight into market opportunities and needs. It reaches almost 1,100 stakeholders from industry, research organisations, and the public sector from all over Europe, and represents trusted and competent advisor to policy-makers. The RHC-ETIP has been instrumental in raising the profile of the renewable heating and cooling sectors through its recommendations for not only research priorities and project ideas, but also for policies.

The presentation will give an overview of RHC-ETIP activities and recommendations and frame the policy developments in the sector in Europe, thereby focussing on the important role of biomass for heating and cooling.

[1] WIP – Renewable Energies; Sylvensteinstraße 2, 81369 München, Germany; +49 89 72012735
[2] The Association of European Renewable Energy Research Centers (EUREC); Pl. du Champ de Mars 2, 1050 Brussels; +32 2 318 40 50

Innovation in Biomass/Waste Gasification Solutions for Generation of Energy and Biofuels

Ashok Chaudhuri, ashok.chaudhuri@ankurscientific.com
Ankur Scientific Energy Technologies Pvt. Ltd.,
www.ankurscientific.com; info@ankurscientific.com, Phone No. +91-265-279-3098
'Anku'r, Near Navrachana School, Sama, Vadodara, Gujarat 390024, INDIA.

Energy is one of the major inputs for the economic development of any country. In the case of the developing countries, the energy sector assumes a critical importance in view of the ever-increasing energy needs. Most Governments of Developing Nations emphasize achieving energy security with target of reducing import dependence of fossil fuels, overcoming of the increasing environmental pollution issues.

One of the large energy sources could be biomass most nations have huge availability of agri-residues and municipal solid wastes, with very little effective use in generation of energy.

One of the very exciting technologies for effective use of biomass and waste is Gasification. Gasification is basically conversion of solid fuels (all various types of biomass, agri-residues & wastes) into a combustible gas mixture normally called Producer or Syn Gas. The process involves partial combustion of such feeds which occurs when air supply (O2) is less than adequate for the complete combustion of biomass/waste. The gas generated can then be used to generate heat, power or make various chemicals and fuels from the same. This technology apart from being extremely clean allows use of the distributed sources in a distributed manner.

Ankur Scientific Energy Technologies Pvt. Ltd., is a Global Technology leader in the field of Biomass & Waste Gasification since 1986. It has developed all its technology in house and has sold more than 1000 gasifiers worldwide – systems have been exported to more than 40 countries across the globe.
While most of the earlier projects were for power or heat, Ankur Scientific has been working on various new initiatives to convert Syngas to Ethanol, Hydrogen and other fuels and chemicals.

HYDROLYSIS OF OXALIS TUBEROSA CARBOHYDRATE TO OBTAIN SECOND GENERATION BIOETHANOL

Magali C. Vivas-Cuellar.[1], Emerson A. Collado D.[2] A. Devorah Arias D. [3] Edgar W. Norabuena M. [4] Olga F. Bullón C. [5] and Oscar G. Marin F.[6]
[1, 2, 4, 5] Facultad de Ingeniería Química y Textil, Universidad Nacional de Ingenieria. [3] Facultad de Ciencias, Universidad Nacional Agraria La Molina [6] School of Chemical Engineering and Bioengineering, Washington State University, EEUU Av. Tupac Amaru 210, Lima 25, Perú, mvivas@uni.edu.pe, ecollado@uni.edu.pe

The contribution of this project is to obtain the optimal conditions for the hydrolysis of the Oxalis Tuberosa carbohydrate, to be transferred to small companies that use agricultural residues.
Therefore, the scientific contribution is to investigate the effect of temperature and enzyme concentration to have a greater conversion of starch into glucose. It is a challenge to generate this new knowledge since in the cited literature it is still incipient in this information.
In addition to strengthening the Biofuels area, providing more results to deepen towards the concept of sustainability and friendly with the ecosystem.

1 INTRODUCTION

The use of waste to obtain starch is an alternative for the sustainable production of bioethanol. Andean tubers such as oca or hibia (Oxalis tuberosa M.) and others have the potential to offer rural populations to contribute to the production of renewable biofuel.
Oxalis tuberosa carbohydrate hydrolysis is carried out by two processes: liquefaction and saccharification. For the mentioned processes, new enzymes will be used that follow the protocol of those already known as alpha amylase and gluco amylase, respectively (see figure 1).
Conditions of temperature, reaction time, and enzyme-to-carbohydrate concentration influence liquefaction and saccharification. In addition to establishing a mathematical model of the hydrolysis process of Oxalis tuberosa.
Andean tubers such as oca or hibia (Oxalis tuberosa M.), olluco (Ullucus tuberosus), mashua or cubio (Tropaeolum tuberosum) and potatoes (Solanum tuberosum ssp. andígena), are crops with the greatest tradition in high Andean communities in South America.

2 MATERIALS AND METHODS

In a stainless steel jacketed reactor, the reaction between the carbohydrate mass and the enzymes will take place, the temperature (90, 60 °C), the carbohydrate/enzyme mass ratio and the hydrolysis time (60, 90 min) are varied. Experiments were conducted in a laboratory-scale setup developed at In faculty of Chemical Engineering of UNI.
2.1 Oxalis tuberosa The oca, papa oca or ibia (Oxalis tuberosa) is a plant that is cultivated in the puna of the central and southern Andes and between 3,000 and 3,900 meters above sea level. n. m. in the northern Andes, for its edible starchy sweet tuber.
2.2 Industrial hydrolysis of starch. Saccharification was carried out in three consecutive stages: gelatinization (90°C and 30 minutes), liquefaction with alpha-amylase (90°C and 60 minutes) and finally saccharification with glucoamylase (60°C and 1 hour). The must obtained in the saccharification stage was standardized and fermented with Saccharomyces cerevisiae yeast. Finally, distillation was carried out.

3 INNOVATION AND CONTRIBUTION

This research is justified because there is a surplus of potatoes, sweet potatoes and others that are sold at very low prices or even discarded, which due to their starch content can be used for the production of bioethanol, giving greater added value to these Peruvian tubers. The importance of the project lies in the fact that the internal needs of bioethanol would be covered, without having to resort to imports and therefore to an outflow of foreign currency from our country. Another important point is that the cultivation of these tubers is promoted in massive quantities for the production of bioethanol, the fuel of the future.

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Sustainable Passive Plus houses with Bio District heating, learnings from a case study in Tarm, Denmark.

SØREN RIIS DIETZ, Bjerg arkitektur-green lab, sd@bjerg.nu, bjerg.nu.

In Denmark 2/3 of building heat is District heating. The political aim is to reduce CO2emissions by 70% in 2030 with 1990 as reference. Buildings make up for 40% of the CO2 emissions – so reducing green house gas from building play a major role.

Greenhouse gas reduction may come from both saving energy and transforming the energy sector to non fossil. Biomass resources are not local grown. Almost 2/3 of Biomass for District Heating is imported. 50% og wood is imported mainly from Russia and the Baltic countries. The demand og wood biomass is 20 Gj, max sustainable production in Denmark is 10Gj[1].

How can Denmark achieve climate goals, in a sustainable way, with Bio District heating with less Biomass – is more building insulation the answer?

A social housing project in Denmark supplied with local Bio district heating is analysed. The buildings are dense row housing in passivehouse plus standard. The District heating plant in the city of Tarm uses biomass Boilers to produce 76% of the heat energy, solar collectors covers 6% and a heatpump additional 18%. Gas and oil back up boilers covers less than 1%. The Net consists of 70 km of tubes.

A Life Cycle Analyze is used to calculate the total emission from the 5 boilers, heatpump, 18.585 m2 solarcollector, buffertanks, pumps, production, store, office building and net. The emission from energy and plant is calculated. Results show a factor 2,02 higher emission pr. kWh and 11% higher than the middle value of danish district heating.

CO2e emission from District heating	**kg/kWh**
Energy	0,035
Denmark middle 0,065 (value without plant and nett loss emission)	
District heat plant	0,023
Net loss	0,013
TOTAL District Heating	0,071

A building with 616 Heated Floor area, and 9 flats is analyzed. PHPPsoftware is used to calculate saved energy by better insulated walls. The emission from insulation material is calculated using LCA software and a balance as saved CO2 emission is the result.

Building energy standard	**Insulation**	**U value**	**Total wall**	**More insulation**	**saved energy**	**Balance saved CO2e by more insulation**
	mm	W/m2K	emission CO2e kg/m2			
2018 < 0,30	110	0,293	1,934			
2020/Passivhus < 0,12	310	0,118	1,993	0,059	3,17	3,111
Passivhus Plus, Tarm Blok 6 HT	390	0,096	2,017	0,083	3,18	3,097

Results show a faktor 38 higher Green house gas emission saving by using higher energy efficiency with Glaswool[2] in buildings saving energy. This reduce the energy needed from district heating – making it possible in the future to cover the need of biomass with local og regional grown bio mass from forest plantations.

[1] https://ens.dk/sites/ens.dk/files/Bioenergi/biomasseanalyse_final_ren.pdf

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„Vorgehensweise des Ersatzes von fossiler Energie durch EE am Beispiel von Textilunternehmen in Indonesien“.

Autoren
Dipl. Ing. Wulf Clemens, Dipl. Ing. Michael Porzig, Dipl. Forstw. Bernhard Wern Email: wern@izes.de
IZES gGmbH Altenkesseler Strasse 17 in 66115 Saarbrücken Deutschland
MA David Morr, Dipl. Forstwirt Ralf Gebhard, Dipl. Phys. Wolfram Kangler Email: r.gebhard@sunfarming.de
SUNfarming Group in 66955 Pirmasens Deutschland

Der Vortrag erfolgt im Kontext des Verbundprojekts EnaTex (2021 – 2024), welches im Rahmen des CLIENT II Programms – Internationale Partnerschaften für nachhaltige Innovationen“ durch das deutsche Bundesministerium für Bildung und Forschung (BMBF) gefördert wird. Ziel des Forschungsprojektes ist die Entwicklung und Demonstration innovativer Ansätze zur Energieeinsparung und Implementierung von Erneuerbaren Energien an ausgewählten Standorten der indonesischen Textilindustrie. Hierbei stehen insbesondere lokale Frisch- und Reststoffbiomassen als Energieträger im Blickpunkt. Der Verbundkoordinator IZES gGmbH und der Partner SUNfarming Group geben einen ersten Einblick in die angewendete Untersuchungsmethodik und stellen die ersten Ergebnisse der Untersuchung vor.

1. Status Quo

Für 2 Gross-Unternehmen der indonesischen Textilindustrie (1,3 Mrd. Umsatz/Jahr) werden an ausgewählten Standorten relevante Energie- und Stoffströme sowie der Anlagenpark auf Verbraucherseite (Maschinen zur Herstellung und Veredelung von Fasern und textilen Flächen) und auf Energieerzeugungsseite (Kessel- und Boileranlagen sowie KWK und Generatoren) aufgenommen. Hierbei werden ebenfalls Abwasser und periphere Ströme, z.B. Bioabfälle aus der Werkskantine, mit berücksichtigt. In einem weiteren Schritt werden die regionalen Potenziale an ausgewählten Erneuerbaren Energie und Biomassen u.a. auf Basis von Nebenprodukten aus der Lebensmittelindustrie und der Landwirtschaft analysiert. Wichtige Punkte sind Mengenverfügbarkeit und aktuelle Nutzungspfade, die im rechtlichen und wirtschaftlichen Kontext auf ihre Verfügbarkeit abgeprüft werden.

2. Senkung Energieverbrauch

Das Projekt von Seiten agieren, den Primärenergieeinsatz durch Effizienzsteigerung verringern und die Energieversorgung zu defossilisieren. Effizienzsteigerung erfolgt durch nicht-investive und investive Massnahmen. In den Untersuchungsfabriken wird 80% der Energie über Wärme, vorrangig Dampf zur Verfügung gestellt. Aktuell wird Ab- und Restwärme nicht genutzt und der Maschinenpark ist nicht in seiner Gesamtheit prozessintegriert. Ein HEN (Heat Exchange Network) wird entwickelt, um medienübergreifend Exergien und Enthalpien der Abwärme zu nutzen und anderen Prozesses als Input-Wärme zuzuführen. Als Methode wird die Pinch-Analyse genutzt und vorgestellt. Das Projekt erwartet Brennstoffeinsparungen von bis zu 30% Endenergie. Add-ons sind die Einbindung von Wärmepumpen auf Basis regenerativer Stromerzeugung auf Basis PV oder Biogas KWK in das System.

3. Recherche PV und andere EE

Im nächsten Schritt werden die Bereitstellung von Strom und Wärme optimiert. 100% der Wärme wird derzeit über Steinkohle bereitgestellt. Der für die textilen Prozesse benötigte Strom wird vollständig über das Stromnetz bezogen und zu 85% aus fossilen Energieträgern, vorrangig Steinkohle, erzeugt. Eine vollständige 100% Umstellung der Stromversorgung auf Basis von Windkraft und PV sind auf Grund des hohen Flächenbedarfs in Kombination mit den erforderlichen Spitzenlasten nicht darstellbar. Im Rahmen der Optimierung werden entsprechende Ansätze zum Lastmanagement strom- und wärmeseitig geprüft. Eine partielle Substitution des Strombezugs wird im Rahmen eines Demonstrators der Firma SUNfarming geprüft, u.a. auf Basis einer PV-Batterie Systems die Klimatisierung der Produktionshallen zu 100% mit EE-Strom zu realisieren.

4. Einsatzoptionen für Biomasse

Vielversprechende Ansätze für den Wärmebereich sind das Co-Firing von Reststoffen aus der Lebensmittelherstellung, insbesondere der Palmölindustrie sowie des Getreideanbaus. Es konnte ein Potenzial von 80.000 Mg/a fester Biomasse eruiert werden, der benötigt wird, um die Wärmeversorgung komplett zu defossilisieren. Mit den anstreben 30% Reduzierung des Energiebedarfs (vgl. Punkt 1) wird auch der Brennstoffeinsatz um 40% reduziert, so dass nur 50.000 Mg/a eingesetzt werden müssen. Weitere Prüfungen erfolgen bzgl. Nutzung von Reststoffen wie industriellen Klärschlämmen und Bioabfällen aus den Werkskantinen sowie der Landschaftspflege der Betriebsgelände mit ca. 80 ha für die Bereitstellung von Biogas im Verbund mit KWK oder Prozessfeuerung. Die Arbeiten werden im Rahmen der nationalen Gesetzgebung und unter Wirtschaftlichkeitsaspekten in Geschäftsmodelle überführt.

Utilization of dilute acetic acid waste streams for ethanol production

Kristian Melin[1]
LUT University, Mukkulankatu 19, Lahti Campus, Finland
Kristian.Melin@lut.fi

Fuel ethanol is mixed in gasoline today to reduce GHG emissions in the transport sector. However, it is still produced mainly from edible first generation feedstock such as corn or sugarcane. More sustainable ethanol is already produced today from straw and wood today in a few plants on commercial scale. Yet the production requires a complex process, and the production cost of ethanol has not been attractive without economic subsidies.

We evaluated in previous work production of ethanol with a high yield through biomass gasification with additional hydrogen input from water electrolysis. The product route involved ethanol production via methanol synthesis, acetic acid synthesis of methanol and carbon monoxide as well as acetic acid hydrogenation into ethanol. In the last step acetic acid can be converted into ethanol with a high efficiency using a relatively simple process. In this study, we consider a process with less production steps, extraction of acetic acid directly from pulp and paper industry prior to pulping or from existing aqueous waste streams in sulphite or semi-mechanical pulping. Extraction of acetic acid employing NaOH to extract acetic acid from acetyl groups in hardwood has already been reported for Kraft pulp mills.

In this study we evaluate the potential for ethanol production in Europe using pulp and paper industry waste streams for acetic acid production. The mass and energy balances of the studied processes are estimated using process simulation models. Both extraction of acetic acid from dilute aqueous streams as well as hydrogenation of acetic acid into ethanol are considered. The models are complemented with literature data for those parts where simulation models and experimental results cannot accurately predict product yields.

There results include product yields, energy consumption of the process per ton of ethanol and need for chemicals in the extraction as well as power input for hydrogen production.

The results indicate that at least several hundred tons of ethanol could be produced annually on a European scale with attractive production cost compared to straw and wood-based bioethanol production. Furthermore, the production process requires fewer step compared bioethanol production from wood or straw residues.

BIG Green Gas – Green gases from dual fluidized bed steam gasification for the Austrian natural gas grid

Katharina Fürsatz[1,2,3,] (katharina.fuersatz@best-research.eu, +43 5 02378-9365)*
Anna Egger[1] (anna.egger@best-research.eu, +43 5 02378-9373)
Florian Benedikt[2] (florian.benedikt@tuwien.ac.at, +43 (1) 58801-166361)
Sascha Grimm[4] (grimm@ovgw.at, +43 1 513 15 88-35)
Matthias Binder[1] (matthias.binder@best-research.eu, +43 5 02378-9355)
Matthias Kuba[1,2] (matthias.kuba@best-research.eu, +43 5 02378-9356)

[1] BEST – Bioenergy and Sustainable Technologies GmbH, Inffeldgasse 21b, 8010 Graz, Austria
[2] Technische Universität Wien, Institute of Chemical, Environmental and Bioscience Engineering, Getreidemarkt 9/166, 1060 Vienna, Austria
[3] Thermochemical Energy Conversion Laboratory, Umeå University, SE-901 87 Umeå, Sweden
[4] Österreichische Vereinigung für das Gas- und Wasserfach, Schubertring 14, 1010 Wien, Austria

As part of the Green Deal, the European Commission has set itself the goal of achieving a climate-neutral Europe by 2050. As early as 2030, CO_2 emissions are to be reduced by 55% compared to 1990. The Austrian Gas and Water Association (ÖVGW) has also committed itself to contributing to the energy transition and is converting the natural gas grid completely to climate-neutral gases by 2040. Gasification of biogenic wastes coupled with downstream synthesis to synthetic natural gas (SNG) and gas conditioning to separate hydrogen are promising approaches to reach a climate-neutral gas grid.

For this, a variety of different biogenic waste streams will be evaluated for their suitability as input for the dual fluidized bed (DFB) steam gasification technology. The goal is to find new feedstocks to produce renewable gases for the gas grid. The investigated feedstocks are not in competition with the food and feed industry and are not intended for use in biogas plants

The most promising feedstocks regarding availability and suitability for the DFB steam gasification technology will be further selected for demonstration in a 1 MW DFB steam gasification plant at Wien Simmeringer Haide. First tests will focus on the evaluation of the newly developed gas cleaning for its suitability to produce a clean synthesis gas suitable for SNG and H_2 production. The newly developed gas cleaning consists of two parts: the coarse gas cleaning units and the fine gas cleaning unit. The coarse gas cleaning contains a cyclone, a ceramic filter, a water quench and a rapeseed oil methyl (RME) scrubber. The fine gas cleaning is executed as temperature swing adsorption to remove left traces of tar and sulfur compounds. The efficiency of both the coarse and fine gas cleaning unit are is determined and their relevance for a future commercial plant evaluated.

This evaluation of biogenic waste stream gasification coupled with extensive gas cleaning will give first indications for future commercial plants regarding design and costs. The obtained data also forms the basis for the full-chain demonstration of gasification and downstream synthesis which will follow at a later time of the project.

Giant Miscanthus and Rapeseed Straw Pyrolysis toward Hydrogen Generation

Slefarski Rafal, Czyzewski Pawel, Szyszka Justyna,
Institute of Thermal Engineering, Poznan University of Technology, 60-965 Poznan, Poland
rafal.slefarski@put.poznan.pl

Introduction

With the huge changes that have sewn up the energy market, especially in the European Union, an even more dynamic transfer of the zero-carbon economy is presumed. In addition to the indisputable environmental benefits, this transformation is expected to combine with ensuring the certainty of supply of energy carriers to European economies. A number of measures are being taken, with one of the main pathways being the use of waste biomass of plant products with a focus on hydrogen production, which can replace natural gas in industry. With the help of pyrolysis technology, fuels such as giant miscanthus and rapeseed straw can be used towards hydrogen production, which is the subject of this work. Additionally the influence of water injection into pyrolysis reactor was investigated.

Methods

Two types of solid fuels derived from biomass were used to carry out experimental study. The first was miscanthus, which is an energy crop. It is characterized by rapid growth and does not need strict soil conditions. Rapeseed straw was chosen as the second fuel. It is a raw material of agricultural origin, which is distinguished by its versatile use (mulch, fodder, pellets). In order to determine the basic properties of the selected solid fuels parameters like moisture, volatile and ash content as well as calorific value were determined. Obtained results were supplemented with thermogravimetric analysis (TGA). The pyrolysis tests for miscanthus and rapeseed straw were carried out under a nitrogen atmosphere with a flow rate of 0.4 dm^3/min. Samples weighing 3-5 g were placed inside the reactor. Three measurements were performed for each fuel at three different heating rates (from 10 to 60ºC/min.). Further tests were realized to check the efficiency of hydrogen production with the addition of water to the reactor. The pyrolysis process continued until the reactor temperature reached 750ºC.

Results

The presented results of measuring the gas composition for each heating rate showed that in terms of hydrogen production the slow pyrolysis process (10ºC/min) proved to be the most efficient. In these heating rates, the calorific value of produced gas is higher. On the other hand, increasing the heating rate resulted in lower H2 content and contributed to a decrease in the calorific value of the obtained gaseous fuel. Moreover, at higher rates of heat delivery (30ºC/min and 60ºC/min) the amount of CO2 has increased. Comparing the two solid fuels in terms of the amount of hydrogen obtained in the pyrolysis gas, the highest results were obtained for rapeseed straw. In terms of calorific value, both miscanthus and straw reached a value of about 10 MJ/m^3. The addition of water to the pyrolysis process significantly affects the amount of hydrogen in resulting gas. Slow pyrolysis (10ºC/min) is the most efficient in terms of hydrogen production and in the most favorable case its content was nearly 54% vol.

Conclusions

Based on the results, it can be concluded that slow pyrolysis process (heating rate10ºC/min) turned out to be the most efficient in terms of hydrogen generation. The highest H_2 values were obtained for thermal conversion of rapeseed straw. The experimental study showed that the heating rate of the reactor has the most significant effect on the chemical composition of the pyrolysis gas. In case of pyrolyzed solid fuel, rapeseed straw generates the highest amount of hydrogen.

The Triple A Process (AmbientAminAbsorption) - Optimization of Biogas Upgrading based on Chemical Scrubbing with Amino Acid Salts for Scalable Expansion of Biomethane Production

*J. Song [a] *, M. O. Schmid [a], J. Güsewell [b], L. Eltrop [b]*

[a] University of Stuttgart, Institute of Combustion and Power Plant Technology (IFK), Stuttgart, Germany
[b] University of Stuttgart, Institute of Energy Economics and Rational Energy Use (IER), Stuttgart, Germany
**Corresponding author. University of Stuttgart, IFK, Pfaffenwaldring 23, D-70569 Stuttgart, Germany, Tel: +49 711-685-66210, E-Mail: jianing.song@ifk.uni-stuttgart.de*

The production structure of raw biogas in Germany is closely connected with the agricultural structure. As a result, it is characterized by smaller biogas plants (BGAs), which are in a performance class > 250 m³/h STP methane. There are similar economies of scale for the costs of common processing technologies, which are especially small for large factories. The biomethane processing plants therefore have an average capacity of 630 m³ N/h. Therefore, there is a need for new, low-cost, small-scale gas upgrading technologies that can also be easily integrated into farm effluent and circulation systems, that is the aim of this study. To achieve this goal, a biogas upgrading process, based on chemical purification (amino acid salts- scrubber), must be optimized at first in the laboratory stud and then upscaled to pilot plant.
The aim of the Triple-A project is to develop a novel robust and small-scale upgrading process. The so-called Triple-A technology uses amino acids (amine) under ambient conditions for chemical gas scrubbing (absorption). The concept and the scrubbing agent used result in advantages that have positive impacts on the operational process, the economic efficiency, and the implementation potential of the technology: (1) The scrubbing agent should be self-extractable from common biogas substrates such as silages and recycled after consumption in the digester and used for local bioeconomic cycles with short distances. (2) The process flow at ambient conditions allows a simple design with low requirements for plant components, safety and professional operation, low energy demand and thus high potential to reduce costs. (3) These characteristics allow a well scalable and cost-optimized operation for upgrading capacities smaller 250 m³ i.N. h.
Next to the problem and concept of the process as well as the corresponding research, the results of the first screening of solvents and the initial operating an established continuously operating plant will be presented. Also, different possible models for the construction of reactors of pilot plant will be introduced.

Wasserstoff via Fermentation und Vergasung Potentiale der Wasserstoffbereitstellung aus Biomasse

Prof. Dr.-Ing. Torsten Birth[1,2] (torsten.birth@haw-hamburg.de)
Natascha Eggers, M.Eng.[1,2,3] (natascha.eggers@iff.fraunhofer.de)
1 Fraunhofer Institut für Fabrikbetrieb und -automatisierung IFF
Energiesysteme und Infrastrukturen | Energie- und Ressourceneffiziente Systeme
39106 Magdeburg | Sandtorstraße 22
2 Hochschule für Angewandte Wissenschaften Hamburg
Department Maschinenbau und Produktion
20099 Hamburg | Berliner Tor 5
3 Technische Universität Dresden
Fakultät Maschinenwesen
01069 Dresden | Helmholtzstr. 10

Wasserstoff aus regenerativen Quellen ist für unterschiedliche Sektoren der bisher einzig bekannte Weg zur klimatechnisch notwendigen, vollständigen Dekarbonisierung.[1]
Der Wasserstoffbedarf Deutschlands lag im Jahre 2020 bei 55 TWh[2]. 95 % davon wurden noch immer auf Basis fossiler Rohstoffe bereitgestellt.[3] Studien haben ergeben, dass dieser fossile Anteil durch den in Folge der Dekarbonisierungspotentiale zunehmenden Wasserstoffbedarf auch bei fortschreitendem Ausbau der Elektrolysetechnologien nicht signifikant sinken wird.[4]–[6]
Um sowohl die aktuelle, als auch die gesteigerte Wasserstoffnachfrage CO_2-arm zu decken, müssen Alternativen zur Elektrolyse untersucht und ausgebaut werden. Alternative Wasserstoffquellen ergeben sich durch biochemische und thermochemische Verfahren aus Biomasse, wie der Biomassevergasung oder der sogenannten Dunkelfermentation.

Am Fraunhofer IFF werden die Potentiale der Integration einer thermochemischen Wasserstoffbereitstellung in existierende Biomassevergaser sowie die Potentiale der Integration fermentativer Wasserstoffbereitstellung in bestehende Biogasanlagen untersucht.
Im Vortrag werden die Potentiale der Dunkelfermentation und der Biomassevergasung zur Bereitstellung von Wasserstoff aus Biomasse aufgeschlüsselt und exemplarisch für Deutschland spezifiziert und visualisiert.

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Optimierte Phosphorrecyclingstrategien vor dem Hintergrund der Rohstoffimportabhängigkeit

Hauptautor:
Sebastian Jentsch, M.Sc. sebastian.jentsch@iff.fraunhofer.de | 0391-4090-727
Fraunhofer Institut für Fabrikbetrieb und Fabrikautomatisierung Abteilung Energiesysteme und Infrastrukturen Energie- und Ressourceneffiziente Systeme Sandtorstraße 22 | 39106 Magdeburg
Co-Autor:
Prof. Dr.-Ing. Torsten Birth torsten.birth@haw-hamburg.de | +49 40 428 75 8704
Professur für Anlagenbau und Prozesssimulation in der Energietechnik Hochschule für angewandte Wissenschaften Hamburg Fakultät Technik und Informatik | Department Maschinenbau und Produktion Institut für Erneuerbare Energien und Energieeffiziente Anlagen ZET Maschinenhalle, Raum 241 Berliner Tor 11 | 20099 Hamburg

Kurzfassung des Vortrages:

Vor dem Hintergrund der novellierten nationalen Rechtssituation (DüMV, AbfKlärV, BBodSchV) wird die Versorgung landwirtschaftlicher Flächen mit Phosphor in Form der bodenbezogenen Klärschlammverwertung infrage gestellt und ist tendenziell als rückläufig anzusehen. Des Weiteren erscheint die Nutzung von Rohphosphaten zu Düngezwecken insbesondere aufgrund der Importabhängigkeit und aktuell politischer Ereignisse, sowie sinkender Rohstoffqualitäten (Uran- und Cadmiumbelastung) im Sinne einer nachhaltigen, kreislauforientierten Bodenbewirtschaftung als nicht darstellbar. Die daraus resultierende Phosphorversorgungs- und Klärschlammentsorgungsproblematik motivieren gleichermaßen Wissenschaft und Forschung zur Erarbeitung neuer ressourceneffizienter Phosphorkreisläufe.

Ausgehend von der Entsorgungsproblematik von Klärschlamm, der mit nennenswerten Massenströmen von 1,8 Mio.-t TS pro Jahr und Phosphorkonzentrationen mit bis zu 3 Ma.-% anfällt, ergibt sich eine Tendenz zur thermischen Verwertung und anschließenden Rückgewinnung des Phosphats aus den Aschen. Die Verfügbarmachung des sekundären Phosphats gestaltet sich jedoch aufgrund der Klärschlammgenese und des nachfolgenden Verbrennungsprozesses als herausfordernd. So werden innerhalb der Abwasserbehandlung Fällmittel zur Überführung des Phosphors in wasserunlösliche Bindungsformen genutzt. Für die gebildeten Metall-Phosphat-Komplexe sind entsprechend der spezifischen Eigenschaften des Kations - vorrangig Eisen und Aluminium - unterschiedliche Aufschlussvermögen anzunehmen. Der Verbrennungsprozess hat ebenfalls Auswirkungen auf das Phosphorrücklösevermögen, insbesondere in Abhängigkeit von Parametern wie Temperatur und Einsatz von Additiven zur Emissionsreduzierung.

Im Rahmen dieser Forschungsarbeit wurden Optimierungsansätze innerhalb der gesamten Wertschöpfungskette untersucht, um eine maximierte Phosphorverfügbarkeit ermöglichen zu können. Insbesondere die Verbrennung, als elementarer Prozessschritt, bietet dabei Variations- und Verbesserungsmöglichkeiten hinsichtlich der eingesetzten Verbrennungstechnologie (insb. Stationäre Wirbelschichtverbrennung), der Verbrennungstemperatur, sowie der Additivzugabe. So konnte festgestellt werden, dass eine Temperaturerhöhung um 50 bis 150 K eine verbesserte Löslichkeit aller in der Asche befindlichen Mineralphasen bewirkt. Neben der Verbrennungsoptimierung werden zudem mechanische (Dichtersortierung der Fraktionen), sowie tribochemische Optimierungsmöglichkeiten zur Erhöhung der Phosphorverfügbarkeit betrachtet.

HyPerFerment – Wasserstoff aus Biomasse Steigerung der Effizienz bestehender Biogasanlagen durch Integration der Dunkelfermentation

Natascha Eggers, M.Eng. 1,2,3 (natascha.eggers@iff.fraunhofer.de)
Prof. Dr.-Ing. Torsten Birth 1,2 (torsten.birth@haw-hamburg.de)
Dr. Fabian Giebner 4 (giebner@micropro.de)
Dustin Heinemann, M.Sc. 5 (dustin.heinemann@streicher-anlagenbau.de)
1 Fraunhofer Institut für Fabrikbetrieb und -automatisierung IFF Energiesysteme und Infrastrukturen | Energie- und Ressourceneffiziente Systeme 39106 Magdeburg | Sandtorstraße 22
2 Hochschule für Angewandte Wissenschaften Department Maschinenbau und Produktion 20099 Hamburg
3 Technische Universität Dresden Fakultät Maschinenwesen 01069 Dresden | Helmholtzstr. 10
4 MicroPro GmbH Mikrobiologisches Labor 39245 Gommern | Magdeburger Straße 26b
5 STREICHER Anlagenbau GmbH & Co. KG 39245 Gommern | Magdeburger Chaussee 21

Im Rahmen der Sektorenkopplung bietet Wasserstoff einen Lösungsansatz für die klimatechnisch erforderliche Dekarbonisierung verschiedener Sektoren.

Im Jahr 2020 lag der Wasserstoffbedarf in Deutschland bei 55 TWh[1] . Durch die Potentiale des Wasserstoffes für die Sektorenkopplung und als alternativer Energieträger für den Strom-, Wärme- und Verkehrssektor wird davon ausgegangen, dass der Bedarf in Deutschland in Zukunft deutlich steigen wird. Klimaschutzszenarien des Öko-Instituts und Fraunhofer ISI gehen von einer Zunahme des Wasserstoffbedarfs um 110 TWh pro Jahr bis 2050 [2] aus. Eine Studie des Bundesverbandes der Deutschen Industrie e.V. nimmt dagegen eine Zunahme des H2 -Bedarfes um 380 TWh pro Jahr bis 2050 [3] an.

Dagegen kommen jedoch Studien des Fraunhofer ISE zu dem Ergebnis, dass bis 2050 lediglich 50 – 80 GW Wasserstoff pro Jahr [4] durch Elektrolyse bereitgestellt werden können. Das entspricht, je nach Studie und Szenario, einem Anteil von 11 - 48 % des erwarteten Gesamtbedarfs.

Um die gesteigerte Nachfrage CO2 -arm zu decken, müssen Alternativen zur Elektrolyse untersucht und ausgebaut werden. Eine alternative Wasserstoffquelle ergibt sich durch die sogenannte Dunkelfermentation, einem Verfahren zur Bereitstellung biologischen Wasserstoffes aus Biomasse. Untersuchungen am Fraunhofer IFF haben ergeben, dass das Potential der Dunkelfermentation in Deutschland bereits heute bei 50 000 Tonnen bzw. 1,66 TWh Wasserstoff pro Jahr liegt. Dies entspricht schon jetzt 3 % des aktuellen Bedarfs in Deutschland. [5]

Im Projekt HyPerFerment II beschäftigt sich das Fraunhofer IFF unter der Leitung der MicroPro GmbH und in Zusammenarbeit mit der STREICHER Anlagenbau GmbH & Co. KG mit der Integration der Dunkelfermentation in bestehende Biogasanlagen. Erste Versuche im Labor- und Technikumsmaßstab legen eine deutliche Effizienzsteigerung nahe, die anhand einer Demonstrationsanlage im 10 m3 -Maßstab belegt werden soll. Die Anlage befindet sich derzeit im Aufbau und soll im Herbst 2022 in Betrieb genommen werden.

Im Vortrag wird der HyPerFerment-Prozess sowie der derzeitige Bearbeitungsstand dargestellt und anhand aktueller Messdaten der Labor- und Demonstrationsanlagen untersetzt.

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Smart Control for Coupled District Heating Networks

Author:
DI Valentin Kaisermayer
BEST – Bioenergy and Sustainable Technologies GmbH, Inffeldgasse 21b/I in 8010 Graz, Austria
valentin.kaisermayer@best-research.eu

Graz University of Technology, Institute of Automation and Control, Inffeldgasse 21b/II in 8010 Graz, A

Co-Authors:
DI Dr. Daniel Muschick
BEST – Bioenergy and Sustainable Technologies GmbH, Inffeldgasse 21b/I in 8010 Graz, Austria
daniel.muschick@best-research.eu

DI Dr. Markus Gölles
BEST - Bioenergy and Sustainable Technologies GmbH, Inffeldgasse 21b/I in 8010 Graz, Austria
markus.goelles@best-research.eu

Univ.-Prof. DI Dr. Martin Horn
Graz University of Technology, Institute of Automation and Control, Inffeldgasse 21b/II in 8010 Graz, A
martin.horn@tugraz.at

District heating (DH) networks will play an important role in transitioning into a carbon natural economy. When communities grow, so do the respective DH networks, and often the opportunity for coupling different DH networks together arises. This creates the need for high-level control concepts that allow for the handling of such coupled DH networks. These networks are often operated by different owners with different economic interests. Any high-level control concept for coupled DH networks must respect this multi-owner energy system structure.

Optimization-based energy management systems (EMS) are a promising high-level control approach for coupled DH networks. These rely on mathematical optimization to devise an optimal operation plan for all production units, taking varying prices, future demand and yield predictions, and operational constraints into account. However, extending an optimization-based EMS for coupled DH networks with a multi-owner structure is non-trivial. This contribution aims to provide an EMS algorithm that supports this task.

The presented concepts were tested on the real-world example of the three DH networks of Leibnitz, Austria. The DH networks are operated by two owners and incorporate biomass boilers, industrial waste heat and a gas backup boiler. The goal is to reduce the overall cost and CO2 emissions of the energy system. Preliminary test results show a reduction in CO2 emissions by 35% and a reduction in fuel costs by 7%.

Utilizing pulverized carbonized woody biomass as additional injectant for blast furnaces – segregation tests in the fluidized bed

1) Richard Deutsch, Dipl.-Ing. BSc. richard.deutsch@best-research.eu
2) Christoph Strasser, Dipl.-Ing. Dr. christoph.strasser@best-research.eu
3) Hugo Stocker, Dipl.-Ing. hugo.stocker@voestalpine.com
1) Norbert Kienzl, Dipl.-Ing. norbert.kienzl@best-research.eu
1) BEST Bioenergy and Sustainable Technologies GmbH, Inffeldgasse 21b in A-8010 Graz www.best-research.eu
2) BEST Bioenergy and Sustainable Technologies GmbH, Gewerbepark Haag 3 in A-3250 Wieselburg-Land www.best-research.eu
3) voestalpine Stahl Donawitz GmbH, Kerpelystraße 199 in A-8700 Leoben, Österreich www.voestalpine.com

Relevance
The production of Iron & Steel still inevitably involves emission of great amounts of carbon dioxide from non-regenerative fuels. The annual increase of worldwide demand in crude steel highlights the need to drastically decrease the specific amount of emitted CO_2 in order to meet the global climate goals. The blast furnace emissions themselves are largely fully minimized as long as only fossil fuels (coke and coal) are considered. One major optimization has been to employ pulverized coal injection (PCI) technology. This technology also offers the option to replace coal by carbonized woody biomass (bioreductant).[1,2] After finishing previous studies on carbonization and pulverization technologies, it appears that the limited availability of suitable biomass and the lengthy process of establishing appropriate supply chains might be the main impeding factor to this approach. To allow for this transition phase and general fuel flexibility contributing to process reliability, the possibility of also a partial replacement of coal by carbonized biomass within the same technical system has been investigated.

Objectives & Approach
The present study focuses on the conveying system employed in PCI, specifically the fluidization and the material outlet. By experimentally investigating the mixing and segregation behaviour of the binary mixture of PCI-coal and bioreductant whilst fluidization with air and drainage in a small fluidization vessel, the stability of the future process can be estimated. To that end, two fluidization columns with air permeable disks at the bottom and a pressurized air supply beneath have been assembled. One assembly was used for testing the mixing/segregation behaviour in the fluidized bed itself (routine A, oriented on ASTM-D6941) and therefore is build with multiple cylindrical segments in the lower part of the column to enable a proper sampling at distinct bed heights. The second assembly was used to record the fluidization graph (pressure drop over superficial gas velocity) and to analyse the mixture quality whilst the drainage of the fluidized bed (routine B) and therefore is equipped with a differential pressure meter beneath and over the powder bed, and a closable discharge pipe through the permeable
disk.
Test runs with different proportions of bioreductant added to the PCI coal in a separate layer prior to fluidization, were performed. After maintaining a fluidized bed for a short period of time fluidization is stopped and thereupon the test bed is separated in different regions and analysed according its constituents, i.e. the mixture quality by assessing the bulk density and/or the content of volatiles. Each test run is performed twice with vice versa layering (routine A). Additionally, each test run is repeated without stopping the fluidization but discharging the fluidized bed through a tube and sampling it by succession (routine B).

Results
Preliminary tentative tests with alternative bioreductant samples highlight the need to evaluate the respective mixing/segregation behaviour of each pairing of powders and fluidization parameters, as the mixture quality appears to be mainly determined by choosing size distributions appropriate to differences in the respective particle density.
For the final bioreductant sample and coal along with their chosen particle size distributions no noteworthy concentration gradients have been recorded at the discharge sequence (routine B). The testing of the mixing/segregation within the fluidized bed (routine B) is currently performed, and results will be available within a few months.

1 Babich, Alexander (2021): Blast furnace injection for minimizing the coke rate and CO2 emissions, Ironmaking & Steelmaking, DOI: 10.1080/03019233.2021.1900037

2 Toloue Farrokh, Najibeh; Suopajärvi, Hannu; Mattila, Olli; Sulasalmi, Petri; Fabritius, Timo (2020): Characteristics of wood-based biochars for pulve¬rized coal injection. In: Fuel 265, p. 117017. DOI: 10.1016/j.fuel.2020.117017.

Hochtemperatur-Prozesswärme aus Biomasse mit integrierter Verwertung von Vergaserrückständen

Autoren:	***Anschrift:***	***E-Mail:***
M. Eng.	*Fraunhofer UMSICHT*	*michael.meiler@umsicht.fraunhofer.de*
Michael Meiler	*An der Maxhütte 1*	
	92237 Sulzbach-Rosenberg	
M.Eng. Dipl.-Wi.-Ing. (FH).	*Fraunhofer UMSICHT*	*martin.meiller@umsicht.fraunhofer.de*
Martin Meiller	*An der Maxhütte 1*	
	92237 Sulzbach-Rosenberg	

Ausgangssituation

In Deutschland benötigt die Industrie mit 657 Terrawattstunden ca. 28% der Endenergie. Davon werden 2/3 für die Bereitstellung von Prozesswärme benötigt. Dies entspricht damit knapp 19% des Endenergiebedarfs in Deutschland. In 2020 wurden mehr als 70 % dieser Prozesswärme mit fossilen Energieträgern (Gas, Öl, Kohle) erzeugt. Nur 6% aus Erneuerbaren Energien und 8% aus Strom.
Trotz dieser Zahlen ist die Prozesswärmewende im Gegensatz zur Wärmewende im Bereich Gebäude in der öffentlichen Diskussion und der politischen Agenda nur ein Randthema. Erst durch die aktuelle geopolitische Lage mit Versorgungsunsicherheiten vor allem mit Erdgas wird etwas klarer wie abhängig vor allem die Industrie davon ist. Während für die Wärmeerzeugung in Gebäuden verschiedene etablierte Alternativen zur Unabhängigkeit von fossilen Energieträgern am Markt verfügbar sind, besteht im Bereich der Prozesswärmeerzeugung enormer Entwicklungsbedarf.
Die Umstellung bestehender fossil befeuerter Prozesse auf elektrische Beheizung ist meist mit enormen Investitions- und Umbaukosten verbunden. Die Umstellung auf den politisch bevorzugten Wasserstoff wird noch Jahr(zehnt)e dauern. Kurzfristiger umsetzbare Alternativen könnte hier der Bioenergiesektor liefern.

Erfolgte Projekte

UMSICHT hat mit Partnern aus der Industrie im Bereich der Prozesswärmebereitstellung mehrere konkrete Anwendungen untersucht.
Im Projekt BioBrick (Biomasse als Schlüssel für eine nachhaltige Produktion von Ziegeln – Energieversorgung, Erzeugung von Prozesswärme und stoffliche Verwertung von Vergaserrückständen) wurde die Integration eines Holzvergasers zur Erdgassubstitution im Tunnelofen geprüft. Zudem wurde die Nutzung von Vergaserkoks als Porosierungsmittel in der Ziegelherstellung untersucht. Neben der technischen Machbarkeit wurden die ökonomische und ökologische Bewertung durchgeführt. Es konnte gezeigt werden, das die Porosierung mit bis zu 0,8 Ma.-% Vergaserkoks möglich ist und dadurch bis zu 20 % Erdgas eingespart werden kann. Brennerversuche mit Holzgas zeigten, dass mit modifiziere Brennertechnik geringe Emissionen, ausreichende Wurflängen und Temperaturen erreicht werden können. Bei Projektende (Anfang 2022) war unter den Rahmenbedingungen eine Einbindung eines Holzvergasers(-BHKW) noch nicht wirtschaftlich, dies scheint aber unter Einbezug der aktuellen Preisentwicklung am Energiesektor absehbar.

Weiteres Vorgehen

Im Anschlussprojekt soll jetzt die praktische Umsetzung, also die Integration eines Holzvergasers an eine Brennergruppe des Ziegelwerks und die direkte Nutzung des erzeugten Vergaserkokses erfolgen und so gezeigt werden, dass eine kontinuierliche Produktion mit Holzgas möglich ist. Durch den ganzheitlichen Projektansatz der neben der thermischen Nutzung des Holzgases auch die Stromerzeugung mittels Holzgas-BHKW enthält soll ein Weg zur CO2-neutralen Ziegelherstellung aufgezeigt werden. Die grundlegende Übertragbarkeit auf andere Ziegelwerke wurde bereits evaluiert.
Um hier noch flexibler zu werden, sprich unterschiedliche Reststoffe nutzbar zu machen, wird derzeit in einem weiteren Projekt (KliSchGa2) die Herstellung von Reststoffpellets und die evtl. Anpassung eines Holzvergasers darauf untersucht. Hier erfolgte im Vorprojekt KliSchGa bereits die Erzeugung verschiedener Pelletmischungen mit einem neuartigen Verfahren. Im aktuellen Projekt soll ein Marktverfügbarer Vergaser für den Betrieb mit den Reststoffpellets optimiert werden. Zudem wird der Vergaser an einen Brennofen in der Keramikindustrie angeschlossen um dort das Gas zu nutzen und das entstehenden Vergaserkoks in den Keramikmischungen als Porosierungsmittel zu nutzen.

Evaluation of different numerical models for the prediction of NOx emissions of small-scale biomass boilers

Michael Eßl [1*], phone: +43 316 873 9223, fax: +43 316 873 9202, email: michael.essl@best-research.eu; Kai Schulze[1], email: kai.schulze@best-research.eu; Robert Scharler [1, 2], email: robert.scharler@tugraz.at; Andres Anca-Couce [2], email: anca-couce@tugraz.at;
[1)] BEST research GmbH, Inffeldgasse 21b, 8010 Graz, Austria
[2)] Institute of thermal engineering, Graz University of Technology, Inffeldgasse 25b, 8010 Graz, Austria

This work investigates a small-scale biomass boiler, which utilizes an under-feed stoker concept with double air staging and softwood pellets as fuel. The goal of the studies is to optimize the boiler in terms of NOx emissions with numerical methods. CFD methods are already well established in science and industry and provide a detailed insight. However, they are very time consuming, when conducted on a full-scale 3D model, which limits the number of parameter variations. This work investigates simplified methods, which can be run in a fraction of time a CFD simulation would require, therefore allowing the variation of multiple parameters. These methods can be applied in an early stage of development to find the optimal design parameters for air-to-fuel ratio, residence time, and temperature to minimize NOx emissions. Furthermore, the methods support the selection of cases in order to perform final CFD-based optimisations.

The numerical studies are conducted with three different methods of varying complexity: (i) a reactor network of zero-dimensional perfectly stirred tank reactors (PSTR), (ii) a reactor network of one-dimensional plug flow reactors (PFR) and (iii) a full-scale 3D CFD simulation. For the CFD method an in-house developed 3D packed bed model for biomass grate furnaces[1] has been expanded and improved to consider the release of NOx precursors at the particle level. For the PSTR and PFR methods the fuel bed is not explicitly modelled, but rather the composition above the fuel bed from CFD is taken as inlet composition for the reactors, which model the secondary and tertiary combustion zone. All methods employ an up to date skeletal reaction mechanisms[2] from literature (37 species and 168 reactions), that includes hydrocarbon as well as nitrogen chemistry.

In the study, the PSTR and PFR methods are compared with the numerically expensive CFD methods and also benchmarked against experimental data. The species composition and temperature of the flue gas at the boiler outlet was selected as the benchmark variable. The reactor network methods showed reasonable agreement with the CFD results as well as experimental data and give valuable indications of possible emission reductions, depending on the mixing behaviour in the combustion chamber. With the computationally inexpensive methods multiple parameter variations e.g. residence time, temperature, reactor volume, are possible to run in a fraction of the time of a CFD analysis. Therefore, design guidelines can be derived faster and the optimization of the boiler is less time consuming.

[1] Shiehnejadhesar A., Mehrabian R., Hochenauer C., Scharler R., The virtual biomass grate furnace - an overall CFD model for biomass combustion plants, Energy Procedia, 2017, Vol. 120, pp. 516-523.

[2] Li T., Skreiberg Ø., Løvås T. & Glarborg P., Skeletal mechanisms for prediction of NOx emission in solid fuel combustion, Fuel, 2019, Vol. 254, pp. 115569

Ökologische und sozio-ökonomische Bewertung grüner Gase - Vergleichende Betrachtung von Biomethan und Wasserstoff aus Biogas

Andreas Herrmann
DBI-Virtuhcon GmbH, Halsbrücker Str. 34, 09599 Freiberg, Tel.: 49 3731 39-4424,
andreas.herrmann@dbi-virtuhcon.de, www.dbi-virtuhcon.de
Lutz Schiffer
Sächsische Akademie der Wissenschaften zu Leipzig, Arbeitsstelle
Technikfolgenabschätzung, Fuchsmühlenweg 9, 09599 Freiberg, Tel.: 49 3731 39-4428,
lutz.schiffer@extern.tu-freiberg.de
Martin Gräbner
TU Bergakademie Freiberg, Institut für Energieverfahrenstechnik und Chemieingenieurwesen,
Fuchsmühlenweg 9, 09599 Freiberg, Tel.: 49 3731 39-4510,
Martin.Graebner@iec.tu-freiberg.de

Die Verfügbarkeit grüner Gase hat sich durch die aktuellen geopolitischen Entwicklungen zu einem zentralen Thema am Gasmarkt entwickelt. Mit der REPowerEU-Initiative der Europäischen Union vom Mai 2022 soll die Biomethanproduktion um Faktor 10 von gegenwärtig 3 auf 35 Mrd. m^3 i.N. bis 2030 gesteigert werden. Der größte Beitrag ist von Deutschland zu erwarten, da hier etwa die Hälfte der in der EU betriebenen Biogasanlagen ansässig sind.

Für die angestrebte Dekarbonisierung des Strombereichs und die sprunghafte Nachfrage nach grünen Gasen stellt insbesondere die Aufbereitung von Biogas zu Biomethan eine zukunftsfähige Alternative zur bisherigen Hauptnutzungsform, der Stromgewinnung, dar.

Bei der katalytischen Biogasmethanisierung lässt sich durch die Nutzung des im Kohlenstoffdioxid enthaltenen Kohlenstoffpotenzials die Biomethanausbeute bei unverminderter Menge an Substrateinsatz nahezu verdoppeln, der Kohlenstoffkreislauf weiter schließen und CO_2-Emissionen reduzieren. Weitere Potenziale ergeben sich durch die Anwendung thermochemischer Konversionsverfahren auf die verbleibenden Gärreste.
Eine weitere Option stellt die Wasserstoffproduktion mittels diverser Reformierungsverfahren dar. Für Biogas wurden insbesondere die autotherme, die trockene sowie die Dampfreformierung entwickelt und getestet. Die besten Ergebnisse wurden mit der Dampfreformierung erreicht.
Zugleich ergeben sich damit neue Optionen der Kopplung der Sektoren Landwirtschaft-Abfallwirtschaft-Verkehr-Wärme-Chemie.

Der Beitrag beschäftigt sich schwerpunktmäßig mit den durch die neuen Marktbedingungen anstehenden Herausforderungen zur Bereitstellung grüner Gase auf Biogasbasis im Kontext der Nachhaltigkeit. Neben der technischen Machbarkeit bedarf es für den erfolgreichen Markteintritt ganzheitlich orientierte Betrachtungen, die sowohl technisch-ökonomische als auch ökologische und soziale Aspekte hinreichend genau abbilden.
Bei der Auswahl der verwendeten Indikatoren liegt der Fokus auf solchen Indikatoren, die derzeit besonders im öffentlichen Interesse stehen und unmittelbare Auswirkungen auf die Akzeptanz haben. Ausgangspunkt bilden Sankey-Diagramme der relevanten Routen zu Stoff- und Energieströmen einschließlich der daraus abgeleiteten Wirkungsgrade.

Aus ökologischer Sicht geht es beispielsweise um verursachte bzw. vermiedene Treibhausgasemissionen sowie Flächenbedarfe, aus ökonomischer Sicht um Anlagen-, Substrat- und Stromgestehungskosten. Soziale Effekte beziehen sich u. a. auf die Bereiche Versorgungssicherheit und Importabhängigkeit. Die Ergebnisse werden im Rahmen einer SWOT-Analyse veranschaulicht.
Vor diesem Hintergrund werden die katalytischen Biogasmethanisierung und die Wasserstoffproduktion vergleichend betrachtet. Für eine umfassende Bewertung werden auch die Folgewirkungen der konventionellen Erdgasgewinnung und Wasserstoffproduktion zum Vergleich herangezogen sowie fördernde und hemmende Faktoren diskutiert.

POTENZIALE WENIG GENUTZTER ABFALLBIOMASSEN ZUR GASERZEUGUNG Erfahrung aus 1.000 Anlagen inkl. Abfallvergasung

Dipl. –Ing. Thomas Bleul
Firma Spanner Re² GmbH
Niederfeldstraße 38
D-84088 Neufahrn i. NB
info@holz-kraft.de

Spanner Re² ist mit ca. 1.000 installierten Holz-Kraft-Anlagen einer der erfolgreichsten Hersteller holzbasierter KWK-Anlagen. Das Unternehmen mit Sitz im niederbayerischen Neufahrn hat sich zu anfangs auf den kleinen Leistungsbereich spezialisiert. Mittlerweile zählt Spanner Re² mit seiner bewährten Holzgas-Technik auch im MW-Bereich zu einer der führenden Hersteller am Weltmarkt.

Die Holz-Kraft-Anlagen basieren auf dem Prinzip der Kraft-Wärme-Kopplung (KWK) und erzeugen aus einer großen Bandbreite an Biomasse, Strom & Wärme. Der zentrale Schritt der Holzvergasung findet im patentierten Reformer statt. Dieser arbeitet im Gleichstrombetrieb, d.h. die Hackschnitzel und das Holzgas bewegen sich in die gleiche Richtung. Das Glutbett ist bei diesem Verfahren besonders kompakt und kontrolliert, was zu einem äußerst sauberen Holzgas führt. Das Holzgas wird dem BHKW zugeführt. Bei dieser Technik der Holzvergasung wird neben Strom gleichzeitig auch Wärme erzeugt und das anders als bei Solar- und Windenergie wetterunabhängig. Die innovative Technik von Re² hält ein weiteres großes Potential bereit: Denn dass, im Holzvergaser produzierte Holzgas kann auch ohne Einsatz eines BHKW als Direktgas genutzt werden. Dadurch lässt sich beispielsweise Erdgas bei Industrieprozessen ersetzen.

Ob Waldhackgut, Waldrestholz, aufbereitetes Straßenbegleitgrün oder geschredderte Obstkisten - ein Holzvergaser von Spanner Re² erzeugt aus nahezu jedem Holz Energie. Holz ist nicht der einzige Brennstoff der verwendet werden kann. Erprobte Alternativen sind Nussschalen, Sonnenblumen oder Kunststoffabfälle was fossile Ressourcen einspart.

Holz-Kraft-Anlagen verfügen über einen breiten Anwendungsbereich. So werden Sie zur Strom & Wärme Erzeugung für Hotels, Landwirtschaften und Holzverarbeitende Betriebe eingesetzt. Auch nutzen Unternehmen die erzeugte thermische Energie für Ihre Prozesse oder nutzen das Holzgas als Ersatz für Erdgas.

Artificial intelligence for selection of relevant publications, data mining, and application of extracted parameters.

Iver Bergh Hvidsten
Faculty of Sciences and Technology, Norwegian University of Life Sciences
Drøbakveien 31, 1432, Ås, Norway
Iver.bergh.hvidsten@nmbu.no
https://www.nmbu.no

Co-Authors: Jorge M. Marchetti
Jorge.mario.marchetti@nmbu.no

Abstract
The fast-growing scientific domain of biodiesel production makes is more and more difficult for a researcher to read and know about all the information within this single topic. The process of manually retrieving information (reading) can thus be said to be infeasible, and therefore this work attempts to use artificial intelligence methods to classify biodiesel production articles, and, in turn, to extract operational parameters from the published work. Initially a keyword in Scopus was used, in this case *biodiesel*, to retrieve a larger collection of references to articles regarding or mentioning biodiesel inside the articles title, abstract or keywords. Next, a test set of 400 abstracts were annotated as either relevant or irrelevant. The relevant articles are the ones that investigate optimisation of biodiesel production, and the irrelevant are all the articles containing something related to biodiesel but are not concerned with optimising a certain reaction. To classify the abstracts, the text is processed in two separate bag of word feature sets. The first approach uses a reduced bag of words with frequencies of selected keywords and phrases that are deemed representative of biodiesel optimization studies. The second feature set is created with scikit-learn count vectorizer function and uses the 1000 most frequent 1,2, and 3-grams. By using more input-features (1000 most frequent words and phrases), the models seem to be able to separate the two classes better than with the reduced bag of words. Furthermore, among the models, a shallow artificial neural network (1000 inputs, 1 hidden layer á 8 nodes with kernel regularization, 50 % dropout before binary classification and class threshold of 0.3) had the best performance on the test set. For this model, the metrics obtained was accuracy = 0.86, recall/sensitivity = 0.94, precision = 0.83, and F1-score = 0.88. For comparison, random forest (the best performing classical machine learning model) showed accuracy = 0.86, recall/sensitivity = 0.85, precision = 0.89, and F1-score = 0.87. Recall or sensitivity, a measure of how many relevant abstracts that was classified as the relevant class, is important for this problem. In the next part of the research, all the documents were inserted into a document-structured database and annotated as relevant or irrelevant using the previous mentioned methods. In addition to machine learning classification, response tables with reactions were used to further limit and exclude false positive articles and to identify the variables used in the publication. With a relatively homogeneous database, two separate search approaches were applied to find the constant parameters. The first uses a text search to match categorical parameters, for instance, which oil, alcohol, catalyst, etc. was used to produce biodiesel. The second approach applies sentence matching patterns using spaCy natural language processing in python, to identify and extract numerical parameters from sentences, like how much oil was used, number of catalytic cycles, volume of reactor, etc. In turn, a dataset of selected reactions can be extracted from the database and investigated (manually and/ or with data science tools), with the goal to decrease the amount of manual labour in screening reactants and components. After selection of components in the reaction, the ranges priorly investigated can help select appropriate levels for new optimization studies.

A thermodynamic analysis of hydrogen production pathways from biomass

Rakesh Narayana Sarma[1], Gokulakannan Senthilvelan[2], Ravikrishnan Vinu[1,2]

[1] Department of Chemical Engineering and National Centre for Combustion Research and Development, Indian Institute of Technology Madras, Chennai, Tamil Nadu 600036 India

[2] X2Fuels & Energy, IIT Madras Research Park, 32, Kanagam Rd, Kanagam, Tharamani, Chennai, Tamil Nadu 600113

Abstract

The present study analyses hydrogen production pathways from biomass. Biomass can be a source for electricity, heat, liquid and gaseous fuels. Thermochemical and biochemical routes can be adapted for transforming waste biomass for clean energy, fuel generation. Hydrogen receives attention as a clean fuel for transportation, power generation and industrial applications. The current work involves comparison of the amount of hydrogen generated through major pathways. Anaerobic digestion produces biogas, which can be purified to obtain Bio-CNG (Compressed Natural Gas). Bio-CNG can be reformed to generate syngas or can undergo methane pyrolysis to generate hydrogen and carbon. Syngas can also be obtained through thermochemical routes like gasification, pyrolysis. Syngas can undergo Water Gas Shift reaction to generate hydrogen. Pressure Swing Adsorption can be a route for separation and production of hydrogen. While most of the processes are catalytic, an estimate of hydrogen production can be obtained thermodynamically. The effects of parameters like fuel composition and temperature on the hydrogen yield from the pathways is discussed. An initial assessment of energy and cost involved with the various pathways can also be presented.

Integrating pulp industry sludge torrefaction with anaerobic digestion: A novel approach to produce bioenergy carriers and biochemicals at improved economic feasibility

Tharaka Rama Krishna C Doddapaneni, Timo Kikas,
Chair of Bioeconomy Technologies, Institute of Forestry and Engineering, Estonian University of Life Sciences, Kreutzwaldi 56, 51006, Tartu, Estonia. tharaka.doddapaneni@emu.ee

Pulp industry sludge is the residue generated during the wastewater treatment at pulp and paper mills, which is rich in organic fraction. In general, around 40 – 50 kg (dry) sludge is produced per ton of paper produced. According to the estimates based on pulp production in 2021, the pulp mills in Europe can generate between 2 – 3 million tons (dry) of pulp industry sludge. Sustainable handling of such large quantities of sludge is a challenge for the pulp mills. Land application, composting, landfilling, anaerobic digestion and incineration are the commonly applied techniques to handle the pulp sludge. However, these methods are not sustainable and involve additional costs for the pulp mills. For example, the landfilling of organic residues is restricted in Europe. Because of the lower methane yield and the presence of process chemicals, anaerobic digestion may not be a feasible solution. Thus, there is a need to develop advanced strategies for the resource recovery from pulp industry sludge.

On the other hand, the economic feasibility of producing bio-based products at commercial scale is not yet fully competitive with the fossil-based counter parts. The reasons include, higher feedstock price, lower product yield, complex and costly pre and post treatments. Thus, in order to improve the overall feasibility of the bio-based products, there is need to produce them from low cost feedstock with higher product yield and at reduced production costs. In that view, using organic wastes as feedstock, producing multiple products by integrating different processes together could be a feasible approach.

In that regard, an innovative process configuration was developed by integrating thermochemical and biochemical conversion processes. To be specific, initially, torrefaction of pulp sludge was carried out to produce torrefied sludge and torrefaction condensate. Later, torrefaction condensate (TC) was used as a substrate in anaerobic digestion (AD) to produce biomethane and volatile fatty acids (VFA). The heating value of the torrefied sludge was in the range of 20 – 22 MJ/kg. In terms of fuel characteristics, the torrefied sludge could be compared with low ranking coal. When it comes to AD, the biomethane potential of the TC varied in the range of 400 – 770 mL/g VS. The VFA yield was in the range of 2 – 4.5 g/g VS. The techno-economic feasibility analysis showed that the minimum selling price of the torrefied pellets can be reduced by 2.5 times in case of pulp sludge compared with torrefied pellets production from wood chips. The selling price of the biomethane and VFA, compared with current market price, could be reduced by 90 and 60%, respectively. To conclude, the developed process for resource recovery from pulp sludge allows to integrate different industries under the concept of industrial symbiosis and can reduce the production costs of bioenergy carriers and biochemicals significantly.

MURREAL - Murtaler Reallabor - On the way to 100% renewable energy by 2040

Project management
Josef Bärnthaler / Energieagentur Obersteiermark GmbH, Holzinnovationszentrum 1a
03577-26664-0, office@eao.st, www.eao.st
Project or cooperation partners
- *DI Petra Busswald / akaryon GmbH*
- *DI Dr. Hartmut Dumke, DI Daniel Youssef / Technische Universität Wien Institut für Raumplanung*
- *DI Dr. Lore Abart-Heriszt, DI Franz Huber / Universität für Bodenkultur Wien Institut für Raumplanung, Umweltplanung und Bodenordnung (IRUB)*
- *Mag. Michael Eder / STRATECO OG*
- *DI Hannah Politor / DI Dr. Stefan Kirchweger / Dipl. Math. Wolfgang Baaske / STUDIA-Schlierbach Studienzentrum für Internationale Analysen*
- *Dr. Günter Wind / Wind - Ingenieurbüro für Physik*
Projektnummer: *FFG-ID (sechsstellige Zahl): 889469*

Synopsis
MURREAL connects the actors of the industrial region Murtal with specialists in the field of high tech and materials with the raw material and energy sector, service providers and research and development. In this exploration for a real laboratory, synergies are to be worked out and business models are to be built up to consistently take the path towards 100% renewable energy and climate neutrality by 2040.

Status: ongoing

- Starting point / motivation

Although the Murtal region with its once classic heavy industry has more or less managed the structural change to innovative high-tech companies, flagship companies and a broad portfolio of materials, there are still numerous challenges, such as the significantly high energy demand (due to the large companies, among others), a population decline or the shortage of skilled workers. Specific challenges with regard to climate protection and energy transition lie - especially in view of "near-natural surroundings" - in the lack of awareness, ignorance and prejudices against renewable energy technologies. On the other hand, the region has a high potential of renewable energy sources and of waste heat and biogenic residual and surplus fractions due to its natural location. An extensive district heating network is also available.

- Contents and goals

The exploratory project MURREAL aims at the creation of a comprehensive development path for a real laboratory to test the energy transition in the district of Murtal, with the clear perspective of a prototypical model solution also for other (similar) regions. Especially since the initial situation in the Murtal is quite representative of numerous similar regions in Austria and beyond:
The Reallabor is an optimal opportunity to use the potentials in a coordinated way, to meet the challenges and to test or advance the energy transition - especially in view of the technical innovations to be included, as well as on the process level to master the organizational-social challenges along the way.
The detailed objectives for the exploratory phase consist of (1) a detailed quantification of the status quo, (2) the development of energy transition scenarios, (3) the conception of the implementation pathway, (4) the conception of the reallaboratory (as an organizational part of the implementation pathway), and (5) the development of a best-practice knowledge platform.

- Methods

The innovations in the exploratory approach lie in the specific application of the Theory of Change approach and in also taking into account the (energy) spatial, economic and legal framework conditions. The following innovations or results are to be generated: (1) Application of tools for an evidence-based, digital, comprehensible, replicable synopsis to an integrative energy system, (2) Evaluation of scenarios in terms of energy and greenhouse gas dimension and with regard to regional value creation, (3) Simulation of innovative technologies and their integration into the future regenerative energy system, among others. Biomass to Liquid (BTL) and Power to Liquid (PTL), (4) conception of the real laboratory with qualitative participation, which ensures effectiveness, implementation and long-term sustainability as well as (5) transferability to similar regions by generating process guidelines digitally-interactively on a best-practice knowledge platform.

- Expected results

The *Energieagentur Obersteiermark* pursues together with regional stakeholders and actors in the Murtal the goal to further develop the region towards climate neutrality. The development and valorization of the regionally available renewable energy, the increase of energy efficiency in buildings and processes, as well as the creation of new synergies in the sense of a sector coupling via electricity-heat-fuels, and also in the interaction of industrial energy systems and waste heat, municipal infrastructures and the urban environment play a major role. This exploratory project is an important step in this direction. It provides a concrete implementation path for a possible future real laboratory including a regional economic evaluation.

Programm Teil 2

Workshops

Parallelblöcke 1-14

Programme Part 2

Workshops

Parallel sessions 1-14

Parallelblock 1

Nachhaltigkeit des Einsatzes von Biomasse für die energetische Nutzung
Saal 5, 09:00 – 10:30

Chair: Luc Pelkmans, *IEA Bioenergy, BEL*

09:00 **Beginn**

Klimabilanzen ausgewählter Wald- und Holznutzungsszenarien
Stefan Füchsl, *TUM Campus Straubing, DEU*

Klimaschutz und Forstwirtschaft
Ernst-Detlef Schulze, *Max-Planck-Institut, DEU*

Integrierter Bewertungsrahmen für die Zertifizierung von geringem Landnutzungsänderungsrisiko
Beike Sumfleth, *DBFZ, DEU*

In ein großes Stahlwerk integrierte Biotreibstoffherstellung aus Altholz – Umwelt- und soziale Auswirkungen
Maria Hingsamer, *Joanneum Research, AUT*

Praxis Erfahrungen aus der Implementierung der RED II
Thomas Siegmund, *SURE Sustainable Resources, DEU*

10:30 **Kaffeepause**

ENERGIE STEIERMARK

Vortragssprache **Englisch**

Parallelblock 2

Biochemische Bioraffinerien
Saal 6, 09:00 – 10:30

Donnerstag 19. Jänner

Chair: Marco Klemm, *DBFZ, DEU*

09:00 **Beginn**

SynGas Fermentation zur Erzeugung von Treibstoffen und Chemikalien aus organischen Reststoffen
Werner Fuchs, *BOKU, AUT*

Einsatz des Biopolymers Chitosan als Flockungsmittel zur Gärrestaufbereitung (FFG Projekt BioFlock)
Wolfgang Gabauer, *BOKU, AUT*

Bioabfall als Ressource für die kombinierte Bereitstellung von Material und Energie: Konzept und Betrieb der Pilotanlage einer Bioraffinerie mit Dampfexplosionsaufschluss und zwei-stufiger anaerober Vergärung als Schlüsselelementen
Gregor Sailer, *Uni Hohenheim, DEU*

Effiziente Synthese von Methanol aus reformiertem Biogas
Carl Fritsch, *FiW RWTH Aachen, DEU*

Innovative Lösungen für die ressourcen- und kosteneffiziente Herstellung von Biomethan in der Landwirtschaft
Kirsikka Kiviranta, *VTT Technisches Forschungszentrum Finnland, FIN*

10:30 **Kaffeepause**

Vortragssprache **Englisch**

Parallel Session 1

Sustainability of biomass for energy solutions
Room 5, 09:00 – 10:30

Chair: Luc Pelkmans, *IEA Bioenergy, BEL*

09:00 **Opening**

Greenhouse gas balances of selected forest und wood utilization scenarios
Stefan Füchsl, *TUM Campus Straubing, GER*

Climate change mitigation and forest management
Ernst-Detlef Schulze, *Max-Planck-Institut, GER*

Integrated Assessment Framework for Low iLUC Risk Certification
Beike Sumfleth, *DBFZ, GER*

Environmental and social impacts of biofuel production using waste wood integrated in a large-scale steel mill
Maria Hingsamer, *Joanneum Research, AUT*

Practical experiences from the implementation of the RED II
Thomas Siegmund, *SURE Sustainable Resources, GER*

10:30 **Coffee Break**

ENERGIE STEIERMARK

Language **English**

Parallel Session 2

Biochemical Biorefineries
Room 6, 09:00 – 10:30

Thursday 19. January

Chair: Marco Klemm, *DBFZ, GER*

09:00 **Opening**

Syngas fermentation for the production of fuels and chemicals from organic residues
Werner Fuchs, *BOKU, AUT*

Utilization of the biopolymer chitosan as coagulation agent for the treatment of digestate (FFG project BioFlock)
Wolfgang Gabauer, *BOKU, AUT*

Biowaste as resource for combined generation of materials and energy: Concept and operation of a pilot-scale biorefinery with steam explosion treatment and two-staged anaerobic digestion as core elements
Gregor Sailer, *Uni Hohenheim, GER*

Efficient methanol synthesis of reformed biogas
Carl Fritsch, *FiW RWTH Aachen, GER*

Innovative solutions for resource- and cost-efficient production of biomethane in agriculture
Kirsikka Kiviranta, *VTT Technisches Forschungszentrum Finnland, FIN*

10:30 **Coffee Break**

Language **English**

Workshop: Highlights der Bioenergieforschung 2023, Saal 1, 09:00 - 12:30

Nationale und internationale Ergebnisse aus den IEA Bioenergy Tasks

Donnerstag 19. Jänner

„Seit Gründung der IEA war Österreich in Forschungsprogramme im Bereich erneuerbare Energien involviert. Derzeit nimmt Österreich an 23 Technologiekooperationsprogrammen (TCPs) teil. Internationale Zusammenarbeit im Bereich der Bioenergieforschung bleibt entscheidend, um den Sektor weiterzuentwickeln und Klimaziele zu erreichen."
Henriette Spyra, Leiterin der Sektion Innovation und Technologie, BMK, AUT

Sabine Mitter,
Abt. Energie- und Umwelttechnologien, BMK

09:00 **Beginn**

Die Veranstaltungsreihe „Highlights der Bioenergieforschung" wurde vom Klimaschutzministerium (BMK) mit dem Ziel ins Leben gerufen, eine Plattform für alle Expert:innen und Stakeholder in diesem Bereich zu schaffen.

Österreich beteiligt sich im Rahmen der IEA Forschungskooperation intensiv an verschiedenen Tasks des Technology Collaboration Programme (TCP) Bioenergy. Ziel ist unter anderem zur Dekarbonisierung der Wärme- und Stromversorgung beizutragen, etwa durch die Substitution fossiler Brennstoffe in der Industrie und die Entwicklung integrierter Bioraffinerien.

Bei „Highlights der Bioenergieforschung" werden aktuelle Entwicklungen und Ergebnisse aus den Tasks vorgestellt. Es erwarten Sie spannende Vorträge zu biobasierten Wertschöpfungsketten für eine zirkuläre Bioökonomie, integrierten Bioraffinerien zur Dekarbonisierung der Industrie, nachhaltige Biomasse-KWK-Anlagen und vieles mehr. Transnationale Forschungs- und Entwicklungsprojekte zur nachhaltigen Nutzung von Bioenergie aus dem ERA-NET Bioenergy stellen einen weiteren wichtigen Schwerpunkt dar.

Die Highlightsveranstaltung findet wie auch vor drei Jahren im Rahmen der **7. Mitteleuropäischen Biomassekonferenz CEBC2023** (18. bis 20. Jänner 2023 in Graz) statt.

Das laufend aktualisierte Programm finden Sie unter:
https://nachhaltigwirtschaften.at/en/events/2023/20230119-highlights-bioenergy.php

Moderation: Hannes Bauer, *BMK, AUT*

09:00 **Begrüßung und Einführung**
Sabine Mitter, *BMK, AUT*

Highlights der IEA Bioenergy
Dina Bacovsky, *BEST, AUT*

Neues aus dem IEA Bioenergy Task 40: Einsatz biobasierter Wertschöpfungsketten
Fabian Schipfer, *TU Wien, AUT*

Neues aus dem IEA Bioenergy Task 32: Verbrennung von Biomasse
Christoph Schmidl/Morten Tony Hansen, *BEST, AUT*

Neues aus dem IEA IETS Annex 11: Industrielle Bioraffinerien
Bettina Muster-Slawitsch, *AEE Intec, AUT*

11:00 **Plenarsession**

Teil 2 der Highlights der Bioenergieforschung 2023 findet Donnerstagnachmittag in der ERA-NET-Session statt.

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

Simultanübersetzung

Workshop: Highlights of Bioenergy Research 2023, Room 1, 09:00 - 12:30

National and international results from the IEA Bioenergy Tasks

Thursday 19. January

„From the beginning of the IEA Austria was involved in renewable energy research programs. Currently Austria participates in 23 technology cooperation programs (TCPs). International collaboration in the field of bioenergy research remains key in order to develop the sector and to approach climate goals."
Henriette Spyra, Head of Directorate General III – Innovation BMK, AUT

Sabine Mitter,
Dept. Energy and Environmental Technologies, BMK

09:00 **Opening**

The series of events „Highlights of Bioenergy Research" was launched by the Federal Ministry of Climate Action, Environment, Energy, Mobility, Innovation and Technology (BMK) with the aim of creating a platform for all experts and stakeholders in this area.

Within the framework of the IEA research cooperation, Austria is intensively involved in various tasks of the Technology Collaboration Program (TCP) Bioenergy. The aim is, among other things, to contribute to the decarbonization of heat and power supply, for example by substituting fossil fuels in industry and the development of integrated biorefineries.

Current developments and results from the tasks are presented in „Highlights of Bioenergy Research". You can expect exciting lectures on bio-based value chains for a circular bioeconomy, integrated biorefineries for the decarbonization of industry, sustainable biomass CHP plants and much more. Transnational research and development projects for the sustainable use of bioenergy from the ERA-NET Bioenergy represent another important focus.

The continuously updated programme can be found at:
https://nachhaltigwirtschaften.at/en/events/2023/20230119-highlights-bioenergy.php

Host: Hannes Bauer, *BMK, AUT*

09:00 **Opening**
Sabine Mitter, *BMK, AUT*

Highlights of IEA Bioenergy
Dina Bacovsky, *BEST, AUT*

Updates from the IEA Task 40: Usage of bio-based value chains
Fabian Schipfer, *TU Wien, AUT*

Updates from the IEA Task 32: Biomass Combustion
Christoph Schmidl/Morten Tony Hansen, *BEST, AUT*

Updates from the IEA IETS Annex 11: Industrial Biorefineries
Bettina Muster-Slawitsch, *AEE, AUT*

11:00 **Plenary session**

Part 2 of Highlights of Bioenergy Research 2023 takes place on Thursday afternoon in the ERA-NET-Session.

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

Simultaneous translation

Veranstaltung: Auszeichnung von Biomasse-Heizwerken und Wärmenetzen durch BMK und klimaaktiv QM Heizwerke, Saal 2, 10:15 - 11:00

Donnerstag 19. Jänner

10:15 **Beginn**

Im Rahmen der **7. Mitteleuropäischen Biomassekonferenz CEBC2023** zeichnen Frau Bundesministerin Leonore Gewessler (BMK) und klimaaktiv QM Heizwerke österreichische Biomasseheizwerke und Nahwärmeprojekte aus. Die Vorzeigeprojekte entsprechen den höchsten technischen sowie wirtschaftlichen Effizienzkriterien und werden für die Nutzung erneuerbarer Energieträger, ihre schlüssigen Gesamtkonzepte sowie das besondere Engagement der AnlagenbetreiberInnen prämiert.

klimaaktiv QM Heizwerke ist ein österreichweites Qualitätsmanagementprogramm für Biomasseheizwerke und Nahwärmenetze. Die Teilnahme daran ist für alle Anlagen in Österreich verpflichtend, deren installierte thermische Gesamtnennwärmeleistung in Summe 400 kW bzw. deren Netzlänge 1000 Trassenmeter erreicht oder übersteigt. Das Managementsystem zielt darauf ab, durch die begleitende Qualitätskontrolle bei Planung, Errichtung und Anlagenbetrieb die technische Qualität und Effizienz der Anlagen zu steigern.

Seit 2014 leitet das **AEE - Institut für Nachhaltige Technologien (AEE INTEC)** im Auftrag des BMK das klimaaktiv QM Heizwerke Programm. Zentrale Bestandteile stellen neben der Begleitung und Weiterbildung der Qualitätsbeauftragten, Planerinnen/Planer und Betreiberinnen/Betreiber auch die Weiterentwicklung des QM-Systems, die Qualitätssicherung sowie der Know-how-Transfer und die Vernetzung aller Stakeholder dar.

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

klimaaktiv

Side-Event: Award of biomass heating plants and heating networks by BMK and klimaaktiv QM Heizwerke, Room 2, 10:15 - 11:00

Thursday 19. January

10:15 **Opening**

In the context of the 7th Central European Biomass Conference CEBC2023, Federal Minister Leonore Gewessler (BMK) and klimaaktiv QM Heizwerke award Austrian biomass heating plants and local heating projects. The showcase projects meet the highest technical as well as economic efficiency criteria and are awarded for the use of renewable energy sources, their coherent overall concepts and the special commitment of the plant operators.

klimaaktiv QM Heizwerke is an Austrian-wide quality management programme for biomass heating plants and local heating networks. Participation is mandatory for all plants in Austria with a total installed thermal capacity of 400 kW or a network length of 1000 meters or more. The aim of the management system is to increase the technical quality and efficiency of the plants through accompanying quality control during planning, construction and operation.

Since 2014, **AEE - Institute for Sustainable Technologies (AEE INTEC)** has been managing the klimaaktiv QM Heizwerke program on behalf of the BMK. In addition to the support and further training of quality officers, planners and operators, central components are the further development of the QM system, quality assurance as well as the transfer of know-how and the networking of all stakeholders.

Bundesministerium
Klimaschutz, Umwelt,
Energie, Mobilität,
Innovation und Technologie

klimaaktiv

Parallelblock 3 Bioenergie – ein notwendiger Teil der Transformation unseres Energiesystems – Potenziale und Notwendigkeiten
Saal 5, 13:30 – 15:00

Chair: Herbert Lechner, *AEA Österreichische Energieagentur, AUT*

13:30 **Beginn**

Die mögliche Rolle von Biotreibstoffen in einem klimaneutralen Transportsektor in Österreich
Gerfried Jungmeier, *Joanneum Research, AUT*

Die Rolle von Biotreibstoffen beim Übergang in ein nachhaltiges Transportsystem
Amela Ajanovic, *TU Wien, AUT*

Wirtschaftlichkeit und Potenziale für biomasse-basierte grüne Gase in Österreich
Reinhard Haas, *TU Wien, AUT*

Die strategische Bedeutung von Bioenergie
Dina Bacovsky, *BEST, AUT*

Förderung der Produktion von Biomethan durch länderübergreifende Eigentumsübertragung von Zertifikaten
Julian Auderieth, *AGCS Gas Clearing and Settlement AG, AUT*

15:00 **Kaffeepause & Posterpräsentation**

Vortragssprache **Englisch**

Parallelblock 4
Treibstoffe aus Bioraffinerien
Saal 6, 13:30 – 15:00

Donnerstag **19.** Jänner

Chair: Tobias Pröll, *BOKU, AUT*

13:30 **Beginn**

Waldrestmassen zur Herstellung von Lebensmitteln und Biotreibstoffen
Shaojun Xiong, *Schwedische Universität für Agrarwissenschaften, SWE*

Demonstration im Labormaßstab der Kopplung eines neuartigen Prozesses zur Reformierung von wässriger Phase mit dem Fischer-Tropsch Prozess
Stefan Arlt, *BEST, AUT*

TO-SYN-FUELS: Nachhaltige Treibstoffe aus Biomassereststoffen – Demonstration in Langzeitversuchen
Stefan Eder, *Fraunhofer UMSICHT, DEU*

Nachhaltige Kraftstoffe für den Flug- und Schiffsverkehr durch hydrothermale Verflüssigung von Zuckerrohrbagasse und Stroh: Techno-ökonomische und ökologische Bewertung
Raquel de Souza, *Universität Campinas, BRA*

Solar-unterstützte hydrothermale Verflüssigung von landwirtschaftlichen Reststoffen
Charikleia Poravou, *CERTH, GRC*

15:00 **Kaffeepause & Posterpräsentation**

Vortragssprache **Englisch**

Parallel Session 3
Bioenergy – an essential part of the transition of our energy system. Potentials and needs
Room 5, 13:30 – 15:00

Chair: Herbert Lechner, *AEA Austrian Energy Agency, AUT*

13:30 **Opening**

The possible role of biofuels in a climate neutral transportation sector in Austria
Gerfried Jungmeier, *Joanneum Research, AUT*

The role of biofuels in the transition toward sustainable transport system
Amela Ajanovic, *TU Wien, AUT*

On the economics and potentials of biomass-based green gases in Austria
Reinhard Haas, *TU Wien, AUT*

The strategic role of bioenergy
Dina Bacovsky, *BEST, AUT*

Facilitating Biomethane production via cross-border ownership transfer of certificates
Julian Auderieth, *AGCS Gas Clearing and Settlement AG, AUT*

15:00 **Coffee Break & Poster Presentation**

Language **English**

Parallel Session 4
BtL Biorefining Processes
Saal 6, 13:30 – 15:00

Thursday **19.** January

Chair: Tobias Pröll, *BOKU, AUT*

13:30 **Opening**

Residual forest biomass for combined production of food and biofuel
Shaojun Xiong, *Schwedische Universität für Agrarwissenschaften, SWE*

Demonstration of the coupling of the novel aqueous phase reforming process with the Fischer- Tropsch process at lab scale
Stefan Arlt, *BEST, AUT*

TO-SYN-FUELS: Sustainable fuels made from biomass residues – demonstration on long-term operating plant
Stefan Eder, *Fraunhofer UMSICHT, GER*

Sustainable aviation and marine fuel from hydrothermal liquefaction of sugarcane bagasse and straw: techno-economic and environmental assessments
Raquel de Souza, *Universität Campinas, BRA*

Solar-aided hydrothermal liquefaction of agricultural waste
Charikleia Poravou, *CERTH, GRC*

15:00 **Coffee Break & Poster Presentation**

Language **English**

Parallelblock 5
Bioenergie in der Praxis
Saal 8, 13:30 – 15:00

Chair: Klaus Engelmann, *LK Steiermark, AUT*

13:30 **Beginn**

QM Heizwerke unterstützt die nachhaltige Wärmewende – Best Practice Beispiele und Benchmarking
Sabrina Metz, *AEE Intec, AUT*

Aktive Rauchgaskondensation mit Absorptionswärmepumpen – Betriebserfahrungen, neue technologische Konzepte und Einsparpotenziale
Harald Schrammel, *Steps Ahead, AUT*

Nachhaltige Energiesysteme, die das Klima retten
Tobias Ilg, *Energiewerke Ilg GmbH, AUT*

Klimawirkung von Biomasse-Kleinfeuerungsanlagen berechnet anhand realer Messdaten des TFZ
Robert Mack, *TFZ Bayern, DEU*

15:00 **Kaffeepause & Posterpräsentation**

Vortragssprache **Deutsch**

Matchmaking im beliebten „Bioenergie-Heurigen"
Saal 14, Mittwoch, 18. bis Freitag, 20. Jänner 10:00 – 17.00

Donnerstag 19. Jänner

Während der gesamten **7. Mitteleuropäischen Biomassekonferenz CEBC2023** haben Sie die Möglichkeit, bei Speis und Trank gemeinsame Geschäftsmöglichkeiten und Synergien im **CEBC-Bioenergie-Heurigen** zu besprechen. Im gemütlichen Ambiente können Sie potenzielle InvestorInnen und GeschäftspartnerInnen aus aller Welt kennenlernen. Das einmalige Matchmaking-Event kann im Anschluss an spannende, wissenschaftliche Vorträge und Workshops besucht werden oder Ihnen als kleine Stärkung zwischendurch dienen. Ergreifen Sie die Gelegenheit und profitieren Sie von der internationalen Ausrichtung der Konferenz. *Prost!*



Parallel Session 5
Bioenergy in Practice
Saal 8, 13:30 – 15:00

Chair: Klaus Engelmann, *LK STMK, AUT*

13:30 **Opening**

„QM Heizwerke" supports the sustainable heat transition – Best practice, examples and benchmarking
Sabrina Metz, *AEE Intec, AUT*

Active flue gas condensation with absorption heat pumps – operating experience, new technological concepts and savings potential
Harald Schrammel, *Steps Ahead, AUT*

The cycle of nature in the biochar-heating plant
Tobias Ilg, *Energiewerke Ilg GmbH, AUT*

Climate impact of biomass small combustion plants calculated using real measurement data from the TFZ
Robert Mack, *TFZ Bayern, GER*

15:00 **Coffee Break & Poster Presentation**

Language **German**

Matchmaking at the popular „Bioenergy-Heurigen"
Room 14, Wednesday, 18th to Friday, 20th of January 10:00 – 17:00

Thursday 19. January

Throughout the **7th Central European Biomass Conference CEBC2023**, visitors have the opportunity to discover common business opportunities and build synergies, while enjoying a glass of wine or beer next to a traditional taste of Austrian cuisine. In a welcoming environment you can meet business partners and investors from all over the world. The unique matchmaking event can be used before or after interesting scientific lectures and workshops and thus, serves as an ideal snack in-between. Take this opportunity and benefit from the international range of the conference. Prost!



ERA-NET Bioenergy – Länderübergreifende Bioenergieforschung im Rahmen der Bioökonomie: Stärkung der energetischen und stofflichen Nutzung biogener Rest- und Abfallstoffe, Saal 9, 13:30 – 15:00

Donnerstag 19. Jänner

„Auch Biomasse ist eine begrenzt verfügbare Ressource. Die Session zeigt anhand von länderübergreifenden Forschungsvorhaben auf, wie man biogene Rest- und Abfallstoffe wertschöpfend energetisch und stofflich nutzen kann."

Chair: Carina Lemke, *FNR, DEU*

„Biomasse ist mit einem Anteil von 53 % am gesamten erneuerbaren Energieverbrauch der wichtigste österreichische erneuerbare Energiesektor. Internationaler Austausch und gemeinsame Forschungsaktivitäten in diesem Bereich ermöglichen industrielle Kreislaufwirtschaft und Energieunabhängigkeit."

Co-Chair: Hannes Bauer, *BMK, AUT*

Teil II der Highlights der Bioenergieforschung findet in dieser ERA-NET-Session statt.

13:30: **Begrüßung**

ERA-NET Bioenergy: Wie Bioenergieforschung an einem Strang ziehen kann
Carina Lemke, *FNR Fachagentur Nachwachsende Rohstoffe, DEU*

BioHEAT – Entwicklung einer auf günstigen biogenen Reststoffen basierenden Prozesskette für die Bereitstellung von Wärme für industrielle Anwendungen
Matthias Kuba, *BEST, AUT*

VARESI – Valorisierung industrieller Reststoffe für eine nachhaltige Industrie
Wolfgang Gabauer, *BOKU, AUT*

Up-Whey – Vorgelagerte Verarbeitung von Lactosemolke für die Produktion von Chemiegrundstoffen und Energie
Michael Mandl, *tbw research, AUT*

PUMA – Rentable 2G-Bioethanolanlagen – Parallele Nutzung von fraktioniertem Lignin in mehreren Anwendungen
Ulla Lassi, *Bisy - Biology for Synthesis, AUT*

16:00 **Ende**

ERA-NET Bioenergy

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

Vortragssprache Englisch

ERA-NET Bionergy – Transnational bioenergy research within the framework of the bioeconomy: Strengthening the energetic and material use of biogenic residues and waste, Room 9, 13:30 – 15:00

Thursday 19. January

„Biomass is also a limited resource. The session will focus on several transnational research projects aiming at improving the valorisation of biogenic wastes and residues for energy and bioproducts."

Chair: Carina Lemke, *FNR, GER*

„The most important Austrian renewable energy sector is bioenergy, amounting 53% of total renewable energy consumption. International exchange and joint research activities in this field enable industrial circular economy and energy independency."

Co-Chair: Hannes Bauer, *BMK, AUT*

Part II of Highlights of Bioenergy Research takes place in this ERA-NET-Session

13:30 **Opening**

ERA-NET Bioenergy: Pulling bioenergy research together
Carina Lemke, *FNR Fachagentur Nachwachsende Rohstoffe, GER*

BioHEAT – Development of a process chain based on opportunity fuels for heat production in industrial processes
Matthias Kuba, *BEST, AUT*

VARESI – Valorisation of industrial residues for a sustainable industry
Wolfgang Gabauer, *BOKU, AUT*

Up-Whey – Upstream processing of lactose whey for bulk chemicals and energy production
Michael Mandl, *tbw research, AUT*

PUMA – Profitable 2G-bioethanol plants – Parallel Use of Fractionated Lignin in Multiple Applications
Ulla Lassi, *Bisy - Biology for Synthesis, AUT*

15:00 **End**

Bundesministerium Klimaschutz, Umwelt, Energie, Mobilität, Innovation und Technologie

ERA-NET Bioenergy

Language English

Parallelblock 6

Emissionsarme und effiziente Verbrennung und Festbettvergasung
Saal 5, 15:30 – 17:00

Chair: Marco Baratieri, *Freie Universität Bozen, ITA*

15:30 **Beginn**

Ofenführerschein – Emissionsminderung durch Schulung des Betreibers eines Kaminofens
Claudia Schön, *TFZ Straubing, DEU*

Vergasung von Altholzfraktionen in einem Schwebefestbett Reaktor
Michael Kresta, *DBFZ, DEU*

Steigerung der Effizienz von Biomassefeuerungsanlagen mit Hilfe einer modularen CO-Lambda Optimierung: Methoden und Ergebnisse aus Langzeitversuchen
Christopher Zemann, *TU Graz, AUT*

Wirtschaftlichkeit von lokalen Biomasseheizwerken am Beispiel Österreichs
Bernhard Mahlberg, *IWI Industriewissenschaftliches Institut, AUT*

Vergaser kleiner Leistung für den landwirtschaftlichen Bereich: Optimierung von Gaserzeuger und Motorprototyp
Valerio Magalotti, *Yanmar R&D Europe S.r.l., ITA*

17:00 **Ende**

Vortragssprache **Englisch**

Parallelblock 7

Politik und Märkte
Saal 6, 15:30 – 17:00

Donnerstag 19. Jänner

Chair: Hubert Röder, *Wissenschaftszentrum Straubing, DEU*

15:30 **Beginn**

Bioenergie: aus Erfahrungen lernen – Rückblick, Status, Ausblick
Manfred Wörgetter, *Senior Consultant, AUT*

Marktentwicklungsunterstützung für intermediäre Bioenergieträger – Ergebnisse des MUSIC Projekts
Rainer Janssen, *WIP Renewable Energies, DEU*

Thermische Veredelung durch Torrefizierung / Karbonisierung, ein Update der Angebots- und Nachfragesektoren
Michael Wild, *International Biomass Torrefaction Council (IBTC), BEL*

Aktuelle und zukünftige weltweite Produktionskapazitäten zur Herstellung von fortschrittlichen Biotreibstoffen
Andrea Sonnleitner, *BEST, AUT*

Bioenergie im Green Deal
Jean-Marc Jossart, *Bioenergy Europe, BEL*

17:00 **Ende**

Vortragssprache **Englisch**

Parallel Session 6

Clean and efficient combustion and fixed bed gasification
Room 5, 15:30 – 17:00

Chair: Marco Baratieri, *Free University of Bolzano, ITA*

15:30 **Opening**

Operating license for stoves – emission reduction by training the operator of a stove
Claudia Schön, *TFZ Straubing, GER*

Gasification of waste wood assortments in a floating fixed bed reactor
Michael Kresta, *DBFZ, GER*

Efficiency increase of biomass combustion systems by a modular CO-lambda optimization: method and results from long-term verification
Christopher Zemann, *TU Graz, AUT*

Cost efficiency of local biomass heating plants: The case of Austria
Bernhard Mahlberg, *IWI Industriewissenschaftliches Institut, AUT*

Small scale agri-gasification: gasifier plus engine prototype optimization
Valerio Magalotti, *Yanmar R&D Europe S.r.l., ITA*

17:00 **End**

Language **English**

Parallel Session 7

Politics and Markets
Room 6, 15:30 – 17:00

Thursday 19. January

Chair: Hubert Röder, *HSWT/TUM Campus Straubing, GER*

15:30 **Opening**

Bioenergy: Lessons learned – historical review, status quo, outlook
Manfred Wörgetter, *Senior Consultant, AUT*

Market uptake support for intermediate bioenergy carriers – MUSIC project results
Rainer Janssen, *WIP Renewable Energies, GER*

Thermal upgrading by Torrefaction/Carbonization, a supply and demand side sector update
Michael Wild, *International Biomass Torrefaction Council (IBTC), BEL*

Production capacity and outlook for advanced biofuels worldwide
Andrea Sonnleitner, *BEST, AUT*

Bioenergy in the Green Deal
Jean-Marc Jossart, *Bioenergy Europe, BEL*

17:00 **End**

Language **English**

Parallelblock 8

Grünes Gas aus Bioraffinerien
Saal 8, 15:30 – 17:00

Chair: Hermann Hofbauer, *TU Wien, AUT*

15:30 **Beginn**

Einsatz von Biomasse zur Herstellung von hochreinem Wasserstoff mittels Chemical Looping
Bernd Stoppacher, *TU Graz, AUT*

Veredelung des Produktgases aus einem kleinen Biomasse Luftvergaser: Erhöhung der Wasserstoffausbeute mithilfe eines Koksbett-Reaktors
Francesco Patuzzi, *Freie Universität Bozen, ITA*

Erste Ergebnisse der Massen- und Energiebilanzierung für eine fortschrittliche 1 MW Zweibettwirbelschicht-Dampf-Gaserzeugungs-Demonstrationsanlage
David Kadlez, *TU Wien, AUT*

Zweibettwirbelschicht-Dampf-Gaserzeugung aus Plastik Rejecten: Teerbildung in einer Pilotanlage mit Gegenstromkolonne und flexiblem Brennstoffeinsatz
Miriam Huber, *BEST, AUT*

ReGas 4 Industry – Gase aus erneuerbaren Reststoffen für die Industrie
Florian Benedikt, *TU Wien, AUT*

17:00 **Ende**

Vortragssprache **Englisch**

Parallelblock 9

Negative Emissionstechnologien auf Basis von Biomasse
Saal 9, 15:30 – 17:00

Donnerstag 19. Jänner

Chair: Tobias Pröll, *BOKU, AUT*

15:30 **Beginn**

Energie- und Massebilanzen biomassebasierter Negative-Emissions-Technologien
Tobias Pröll, *BOKU, Wien, AUT*

Überblick über den neuen Kommissionsvorschlag zur EU-Zertifizierung des Kohlenstoffabbaus und nächste Schritte im Gesetzgebungsverfahren
Ennio Prizzi, *Bioenergy Europe, BEL*

Erkenntnisse aus der BECCS-Pilotanlage von Stockholm Exergi
Vertreter von Stockholm Exergi, SWE*

Mögliche CO_2-Abscheidetechnologien für Biomassekraftwerke und Müllverbrennungsanlagen
Tbd.

Technisches Speicherpotenzial für biogenes CO_2 in den geologischen Strukturen Österreichs
Tbd.

17:00 **Ende**

** angefragt*

Vortragssprache **Englisch**

Parallel Session 8

Green gas biorefining processes
Room 8, 15:30 – 17:00

Chair: Hermann Hofbauer, *TU Wien, AUT*

15:30 **Opening**

Utilization of biomass for high-purity hydrogen production with chemical looping
Bernd Stoppacher, *TU Graz, AUT*

Upgrading of producer gas from small scale biomass air gasification: hydrogen yield enhancement over a char bed reactor
Francesco Patuzzi, *Free University of Bolzano, , ITA*

First results of mass and energy balances of a 1 MW advanced dual fluidized bed steam gasification demonstration plant
David Kadlez, *TU Wien, AUT*

Dual fluidized bed steam gasification of plastic rejects: Behavior of tar formation in a pilot plant with a counter-current column and flexible fuel input
Miriam Huber, *BEST, AUT*

ReGas 4 Industry – Gases from renewable residual sources for industry
Florian Benedikt, *TU Wien, AUT*

17:00 **End**

Language **English**

Parallel Session 9

Biomass-based negative emission technologies
Room 9, 15:30 – 17:00

Thursday 19. January

Chair: Tobias Pröll, *BOKU, AUT*

15:30 **Opening**

Energy and mass balances of biomass-based negative emission technologies
Tobias Pröll, *BOKU, Wien, AUT*

Overview on the new Commission Proposal on the EU certification for carbon removals and next steps in the legislative process
Ennio Prizzi, *Bioenergy Europe, BEL*

Findings of the BECCS pilot plant at Stockholm Exergi *Vertreter von Stockholm Exergi*, SWE*

Possible CO_2 capture technologies for biomass power plants and waste incineration plants
Tbd.

Technical storage potential for biogenic CO2 in the geological structures of Austria
Tbd.

17:00 **End**

** requested*

Language **English**

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WINTERTAGUNG 2023
FACHTAG WALDWIRTSCHAFT

ÖKO SOZIALES FORUM

PROGRAMM

Block I: Zukunft der Waldwirtschaft - Welche Rolle spielt die Kreislaufwirtschaft?

09.00 Eröffnung und Begrüßung
09.10 Europäische Perspektive für die Branche Waldwirtschaft
09.25 Die Rolle der Leistungsfähigkeit der europäischen Wälder für eine resiliente EU
09.40 Kreislaufwirtschaftsstrategie – Bedeutung für die Waldwirtschaft
09.55 Bioökonomie und Kreislaufwirtschaft aus Sicht der Wald- und Holzpolitik

Block II: Kreisläufe in der Waldwirtschaft schließen

11.00 Materialkreislauf - Ansprüche an den Rohstoff Holz
11.25 Kohlenstoffkreislauf - Was Bioökonomie leisten kann
11.50 Energiekreislauf - Raus aus der Abhängigkeit
12.15 Podiums- und Publikumsdiskussion: Österreichs Weg zu mehr Bioökonomie durch aktive Waldbewirtschaftung

Freitag, 20. Jänner
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Parallelblock 10

Abfallbasierte Bioraffinerietechnologien für die Beschleunigung der Einführung und Umsetzung nachhaltiger Energieprozesse – Spezielle Session von WIRE – Cost Action 20127, Saal 6, 09:00 – 10:30

Chair: Katharina Fürsatz, *BEST, AUT*

09:00 **Beginn**

Biomasse als nachhaltiger und erneuerbarer Rohstoff für eine grünere Zukunft
Rui Galhano dos Santos, *C5Lab, CERENA, IST-Ulisboa, POR*

Energetisches Nutzungspotential von auf schwermetallbelasteten Böden kultiviertem Schilf
Leandro Gomes, *NOVA School of Science and Technology, POR*

Ein vereinfachtes kinetisches Modell für Pyrolyse und Vergasung von Biomasse: Status, Herausforderungen und Perspektiven
Alessio Frassoldati, *Politecnico Milano, ITA*

Biomethan aus wildem Zuckerrohr (Saccharum spontaneum L. ssp. Aegyptiacum) kultiviert auf schermetallbelasteten Böden
Barbara Rachele Ciaramella, *Universität Catania, ITA*

Integration von Bioraffinerien in eine Biomasseanlage für die CO2-freie Bereitstellung von Bioenergie
Charalambo Chasos, *Frederick Universität Zypern, CYP*

10:30 **Kaffeepause**

Vortragssprache **Englisch**

Parallelblock 11

Digitale Methoden und Werkzeuge Saal 7, 09:00 – 10:30

Freitag 20. Jänner

Chair: Markus Gölles, *BEST, AUT*

09:00 **Beginn**

Mehrskalen-Modellentwicklung für biomasse-basierte Chemical Looping Prozesse
Thomas Steiner, *BEST, AUT*

Einsatz flexibler Werkzeuge für energieintensive Industrien
Nikolaos Margaritis, *CPERI & CERTH, GRC*

Optimierung des Nutzens von biomasse-basierten hybriden Anlagen im Zusammenhang mit zellulären Systemen
Lukas Richter, *DBFZ, DEU*

Entwicklung eines digitalen Zwillings für eine SNG-Pilotanlage
Stefan Jankovic, *TU Wien, AUT*

Betriebsoptimierung und Fehlererkennung in Biomassekesseln durch modell-basiertes Monitoring: Methoden und praktische Anwendung
Christopher Zemann, BEST & *TU Graz, AUT*

10:30 **Kaffeepause**

Vortragssprache **Englisch**

Parallel Session 10

Waste biorefinery technologies for accelerating sustainable energy processes – Special session of WIRE – CA20127, Room 6, 09:00 – 10:30

Chair: Katharina Fürsatz, *BEST, AUT*

09:00 **Opening**

Biomass as a sustainable and renewable raw material for a greener future
Rui Galhano dos Santos, *C5Lab, CERENA, IST-Ulisboa, POR*

Valorization potential for energy of Arundo donax biomass cultivated in heavy metal contaminated soils
Leandro Gomes, *NOVA School of Science and Technology, POR*

A semi-detailed kinetic model for biomass pyrolysis and gasification: status, challenges and perspectives
Alessio Frassoldati, *Politecnico Milano, ITA*

Biomethane production from African fodder cane biomass cultivated in heavy metal contaminated soils
Barbara Rachele Ciaramella, *Universität Catania, ITA*

Biorefinery technologies integration in a biomass unit for bioenergy production and zero-carbon emissions
Charalambo Chasos, *Frederick Universität Zypern, CYP*

10:30 **Coffee Break & Poster Presentation**

Language **English**

Parallel Session 11

Digital Methods and Tools Room 7, 09:00 – 10:30

Friday 20. January

Chair: Markus Gölles, *BEST, AUT*

09:00 **Opening**

Development of multi-scale models of biomass based chemical looping processes
Thomas Steiner, *BEST, AUT*

Application of flexible tools in energy intensive industries
Nikolaos Margaritis, *CPERI & CERTH, GRC*

Optimizing the value of solid biomass-based (hybrid) systems in the context of the cellular approach
Lukas Richter, *DBFZ, GER*

Design of a digital twin for a pilot plant for synthetic natural gas production
Stefan Jankovic, *TU Wien, AUT*

Operational optimization and error detection in biomass boilers by model-based monitoring: methods and practice
Christopher Zemann, BEST & *TU Graz, AUT*

10:30 **Coffee Break & Poster Presentation**

Language **English**

Workshop: Thermische Veredelung von Biomasse durch Torrefizierung und Karbonisierung
Saal 8, 09:00 - 10:30

Vortragssprache Englisch

Freitag 20. Jänner

Chair: Michael Wild, *Wild&Partner, IBTC, BEL*

In seinem Workshop werden einige der erfolgreich umgesetzten Torrefizierungsinitiativen vorgestellt und die Entwicklung vom reinen Brennstoffprodukt zum metallurgischen Prozessinput und höherwertigen Produkten aus karbonisierter Biomasse diskutiert. Auf die einführenden Präsentationen folgt eine Podiumsdiskussion, die auch das Publikum einlädt, sich zu beteiligen.

Über die IBTC: Torrefizierte Biomasse ist einer der fortschrittlichsten festen Biobrennstoffe mit dem Potenzial, ein standardisiertes Gut und eine greifbare Alternative zu fossilen Brennstoffen auf globaler Ebene zu werden. IBTC wurde gegründet, um die Verwendung von torrefizierter Biomasse zu fördern und die Entwicklung seiner Industrie auf der Grundlage fairer Geschäftsbedingungen zu unterstützen. IBTC setzt sich dafür ein, die Verwendung von torrefizierter Biomasse als effizienten Energieträger zu fördern, der den globalen Übergang zu einem CO2-neutralen Energiesystem bis 2050 beschleunigen kann. biomasstorrefaction.org

09:00 Eröffnung

Internationaler Biomasse-Torrefizierungs und Karbonisierungs Rat (IBTC) – neue Entwicklungen
Michael Wild, *Wild&Partner & IBTC, BEL*

Green Coal – neue Karbonisierungstechnologien
Lukas Schirnhofer, *Polytechnik, AUT*

Abseits vom Holz: Alternative Biomasse zur Torrefizierung
Wolfgang Moser, *NextFuel, SWE/AUT*

Ökologisch nachhaltige Bindemittel – Warum Bindemittel kein notwendiges Übel, sondern Türöffner zu mehr Effizienz und Potenzialen sind
Carsten Mergelmeyer, *C&D, GER*

10:00 **Podiumsdiskussion**

10:30 Ende

Außenaufnahme der Anlage Green Carbon mit den in BIG BAGs abgefülltem carbonisierten Material ©Polytechnik

Workshop: Thermal upgrading of Biomass by Torrefaction and Carbonization
Room 8, 09:00 - 10:30

Language English

Friday 20. January

Chair: Michael Wild, *Wild&Partner, IBTC, BEL*

In this workshop some of the successfully implemented torrefaction initiatives will be presented and the development from pure fuel product to metallurgical process input and higher value products from carbonized biomass will be discussed. The introductory presentations will be followed by a panel discussion, which also invites the audience to participate.

About the IBTC:
Torrefied biomass is one of the most advanced solid biofuels and the only viable source of renewable solid carbon, with the potential to become a standardised commodity and a tangible alternative to fossil fuels and fossil carbon on all levels at a global scale. The IBTC sees sustainably produced torrefied biomass efficiently replacing fossil coal in all industries and applications and sequestring atmospheric carbon permanent into the soil by this speeding up the global transition towards a carbon-neutral economy and the limitation of CO2 in the atmosphere.
biomasstorrefaction.org

09:00 Opening

International Biomass Torrefection and Carbonisation Council (IBTC) – new developments
Michael Wild, *Wild&Partner, IBTC, BEL*

Green Coal – new carbonization technologies
Lukas Schirnhofer, *Polytechnik, AUT*

Non-woody biomass: Pushing towards alternative feedstock for torrefaction
Wolfgang Moser, *NextFuel, SWE/AUT*

Natural Based Binders - Why binders are not a necessary evil, but rather a performance enhancer that also opens new doors
Carsten Mergelmeyer, *C&D, GER*

10:00 **Panel discussion**

10:30 End

Exterior photo of the Green Carbon plant with the carbonized material filled in BIG BAGs filled carbonized material ©Polytechnik

WS: Nahwärmeverbund 4.0
Saal 9, 09:00 – 12:30

Freitag 20. Jänner

„ACR-Institute sind ausgelagerte Forschungsabteilungen für KMU, die gleichzeitig Unterstützung bei alltäglichen Problemen bieten."

Chair: Richard Zweiler, *GET, AUT*

ACR (Austrian Cooperative Research) als größte F&E-Organisation Österreichs für angewandte Forschung unterstützt kleine und mittlere Unternehmen im Sinne einer externen F&E-Abteilung.

Die ACR-Institute AEE - Institut für Nachhaltige Technologien (AEE INTEC), Güssing Energietechnologien (GET), Industriewissenschaftliches Institut (IWI) und der Österreichische Kachelofenverband (KOV) haben eine gemeinsame Plattform mit dem Namen „Nahwärmeverbund 4.0" ins Leben gerufen. Sie entwickelten eine Reihe von Tools zur Optimierung von Nah- und Fernwärmeanlagen. Zur Unterstützung der Betreiber werden die Ergebnisse der Analysen ausgewählter Anlagen sowie des F&E-Portfolios präsentiert.

Chair: Richard Zweiler, *GET, AUT*

09:00 **Beginn**

Vorstellung des Nahwärmeverbunds 4.0
Klaus Paar, *GET, AUT*

Benchmarking von Biomasse-Heizwerken
Christian Ramerstorfer, *AEE, AUT* & Bernhard Mahlberg *IWI, AUT*

Aktuelle Herausforderungen aus Betreibersicht
Anton Taschner, *Bio Fernwärme Sieggraben eGen & Heizwerkeverband Burgenland, AUT*

Förderungen für Biomasse-Nahwärme
Christof Horvath, *KPC, AUT*

World-Cafe zu den Fragen der aktuellen Herausforderungen für Biomasse-Heizwerke, kurzfristige Lösungen der Probleme und benötigte Unterstützung durch Externe
Gastgeber der Tische des World-Cafe: AEE, GET, IWI

Zusammenfassung der Workshop-Resultate und Abschluss
Richard Zweiler, *GET, AUT*

12:30 **Mittagspause & Posterpräsentation**

Vortragssprache **Deutsch**

WS: District heating network 4.0
Room 9, 09:00 – 12:30

Friday 20. January

„ACR institutes are outsourced research departments for SMEs, which at the same time offer support for day-to-day problems."

Chair: Richard Zweiler, *GET, AUT*

ACR (Austrian Cooperative Research) as the largest R&D organization in Austria for applied science supports small- and medium enterprises in terms of an external R&D department.

The ACR-institutes AEE - Institute for Sustainable Technologies (AEE INTEC), Güssing Energy Technologies (GET), Institute for Industrial Research (IWI) and the Austrian Tiled Stove Association (KOV) have started a joint platform called "Nahwärmeverbund 4.0", wherein they developed a series of tools for optimization of district heating plants. The outcomes of the analysis of selected district heating systems as well as the R&D-portfolio will be presented to support district heating operators.

Chair: Richard Zweiler, *GET, AUT*

09:00 **Opening**

Presentation of the local heating network 4.0
Klaus Paar, *GET, AUT*

Benchmarking of biomass heating plants
Christian Ramerstorfer *(AEE)* & Bernhard Mahlberg *(IWI), AUT*

Current challenges from the operator's point of view
Anton Taschner, *Bio Fernwärme Sieggraben eGen & Heizwerkeverband Burgenland, AUT*

Subsidies for biomass local heating
Christof Horvath, *KPC, AUT*

World Cafe on the questions of the current challenges for biomass heating plants, short-term solutions to the problems and required external support
Gastgeber der Tische des World-Cafe: AEE, GET, IWI

Summary of workshop results and conclusion
Richard Zweiler, *GET, AUT*

12:30 **Lunch break & poster presentation**

Language **German**

Parallelblock 12

Biomasse Brennstoff und Aschecharakterisierung
Saal 6, 11:00 – 12:30

Chair: Hans Hartmann, *TFZ Straubing, DEU*

11:00 **Beginn**

Charakterisierung von Altholz für den Einsatz in der Vergasung im Schwebebettverfahren
Anna Szepannek, *MCI Management Center Innsbruck, AUT*

Erfüllen recycelte Holzsortimente immer die Kriterien für die Verbrennung?
Martin Weigl-Kuska, *Holzforschung Austria, AUT*

Monitoring der Qualität von eingesetzten Hackgutsortimenten
Josef Rathbauer, *HBLFA Francisco Josephinum - BLT Wieselburg, AUT*

Exakte Bestimmung des anwendungskritischen Parameters Cr(VI) in den Aschen von Biomasseheizwerken
Michael Ecker-Eckhofen, *BEST, AUT*

Genauere und raschere Bestimmung von Parametern mit Auswirkung auf den Heizwert von festen Brennstoffen
Anne Mette Frey, *DTI Dänisches Technologieinstitut, DNK*

12:30 **Mittagspause & Posterpräsentation**

Vortragssprache **Englisch**

Parallelblock 13

Freitag 20. Jänner

Flexible Bioenergie und biomasse-basierte hybride Energiesysteme
Saal 7, 11:00 – 12:30

Chair: Daniela Thrän, *UFZ Helmholtz-Zentrum für Umweltforschung, DEU*

11:00 **Beginn**

Überblick über flexible Bioenergielösungen und deren Implementierung
Daniela Thrän, *UFZ Helmholtz-Zentrum für Umweltforschung, DEU*

Erhöhung der Brennstoffflexibilität von Biomassefeuerungen durch Online-Sensoren
Jürgen Oischinger, *Fraunhofer UMSICHT, DEU*

Erhöhung der Flexibilität von Biomasse-Festbettvergasern durch modellbasierte Regelungsstrategien: Methoden und praktische Verifizierung
Clemens Hollenstein, *TU Graz & BEST, AUT*

Lösungen und Elemente zur Flexibilisierung biomasse-basierter Nah- und Fernwärmenetze
Joachim Kelz, *AEE – Institut für Nachhaltige Technologien, AUT*

Prädiktive Regelung von Biomasse- und Biogas-KWKs an der Schnittstelle zwischen Strom- und Wärmenetzen - Verbesserung der Partizipation am Strommarkt durch Optimierung und Management der Nachfrageseite
Daniel Muschick, *BEST, AUT*

12:30 **Mittagspause & Posterpräsentation**

Vortragssprache **Englisch**

Parallel Session 12

Biomass fuel and ash characterization
Room 6, 11:00 – 12:30

Chair: Hans Hartmann, *TFZ Straubing, GER*

11:00 **Opening**

Characterisation of waste wood for the use in floating fixed bed gasification
Anna Szepannek, *MCI Management Center Innsbruck, AUT*

Do recovered wood streams always fulfill criteria for combustion?
Martin Weigl-Kuska, *Holzforschung Austria, AUT*

Quality monitoring of practical wood chips samples
Josef Rathbauer, *HBLFA Francisco Josephinum - BLT Wieselburg, AUT*

Accurate determination of the application critical parameter Cr(VI) in Biomass Ash
Michael Ecker-Eckhofen, *BEST, AUT*

Towards a more accurate and fast determination of parameters impacting the calorific value of solid biofuels
Anne Mette Frey, *DTI Dänisches Technologieinstitut, DNK*

12:30 **Lunch Break & Poster Presentation**

Language **English**

Parallel Session 13

Friday 20. January

Flexible bioenergy and biomass-based hybrid energy systems
Room 7, 11:00 – 12:30

Chair: Daniela Thrän, *UFZ Helmholtz-Zentrum für Umweltforschung, GER*

11:00 **Opening**

Overview on flexible bioenergy options and implementation
Daniela Thrän, *UFZ Helmholtz-Zentrum für Umweltforschung, GER*

Increasing the fuel flexibility of biomass firing systems through online sensors
Jürgen Oischinger, *Fraunhofer UMSICHT, GER*

Increasing the flexibility of a fixed-bed biomass gasifier through model-based control strategies: method and practical verification
Clemens Hollenstein, *TU Graz & BEST, AUT*

Solutions and elements for the flexibilization of biomass-based district heating grids
Joachim Kelz, *AEE – Institut für Nachhaltige Technologien, AUT*

Predictive control of biomass and biogas-based CHPs at the intersection between the electricity grid and heating networks – Improving electricity market participation through optimization and demand side management
Daniel Muschick, *BEST, AUT*

12:30 **Lunch Break & Poster Presentation**

Language **English**

Workshop: Biokohle, Saal 8, 11:00 – 15:00

Vortragssprache Englisch

Freitag 20. Jänner

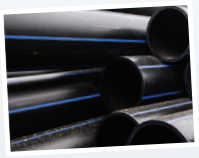
Biokohle – Der Wertstoff im Werkstoff

„Biokohle ist mehr als nur eine Kohlenstoffsenke. Biokohle-Kompositwerkstoffe liefern einen wesentlichen Beitrag zur Erreichung von Klimazielen, können die Produktqualität verbessern und gleichzeitig ökonomisch sinnvoll sein."

Chair: Stefan Martini, *BEST, AUT*

Die Diversität der Biokohlen ist aufgrund der Ausgangsmaterialien und Herstellverfahren immens groß. Durch entsprechende Nachbereitungsprozesse kann diese noch erweitert werden. Diese Bandbreite und Flexibilität kann in sogenannten Komposit-Werkstoffen genutzt werden, um maßgeschneiderte Materialeigenschaften zu erzielen. Neben der Substitution von fossilen Kohlenstoffen, welche heute in zahlreichen Industrieprozessen (noch) nicht wegzudenken sind (Aufkohlung von Stahl- und Guss-Werkstoffen, chemische Industrie, etc.) kann biogener Kohlenstoff durch seine vielseitigen Erscheinungsformen auch neue Möglichkeiten eröffnen. Im Workshop wird die Nutzung von Biokohle als Werkstoff-Komponente anhand aktueller Projekte z.B. im Bereich Kunststoff und Beton aufgezeigt. Es wird die Möglichkeit geschaffen, mit Experten, auf sowohl der Hersteller- als auch der Anwenderseite, die Potentiale der Biokohle als Wertstoff, die notwendigen Schritte zu deren weiterer Erschließung, aber auch Fehlentwicklungen zu diskutieren.



11:00 **Eröffnung und Workshop-Einführung**
Stefan Martini, *BEST, DEU*

Biokohle – Eigenschaften als Werkstoffkomponente
Marco Baratieri, *Freie Universität Bozen, ITA*

Erfahrungen in Polymerkomposit-Herstellung mit Biokohle
Andrea Brunetin, *NADIR, ITA*

Dielektrische Eigenschaften von Biokohlen, Biokohle-Polymer-Kompositen und mögliche Anwendungen
Oliver Pischler, *TU Graz, IHS, AUT*

Diskussion

Vorstellung des Green Carbon Lab
Elisabeth Wopienka, *BEST, AUT*

12:30 **Mittagspause**

Projektvorstellung Alps4greenC – Umsetzungswege für die nachhaltige Produktion von grünem Kohlenstoff
Konstantin Moser, *BEST, AUT*

Grüner Beton – vom Klimakiller zum Klimaretter
Axel Preuß, *CarStorCon Technologies, DEU*

Elektrisch leitfähige Biokomposite auf der Basis von PHBV und aus Holz gewonnenen Kohlenstoff-Füllstoffen
Christoph Unterweger, *Wood K plus, AUT*

Grüner Kohlenstoff als Trägermaterial in Brennstoffzellen
Minoj Gnanaseelan*, *FILK Freiberg Institute, DEU*

15:00 **Ende**

** angefragt*

Workshop: Biochar, Room 8, 11:00 – 15:00

BEST Bioenergy and Sustainable Technologies

Language English

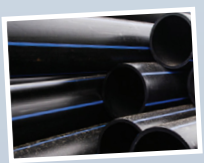
Biochar – a valuable additive for advanced materials

„Biochar is more than just a carbon sink - biochar composite materials make a significant contribution to achieving the climate goals, can improve product quality and at the same time be economically sensible."

Chair: Stefan Martini, *BEST, AUT*

Biochar convinces with its high level of diversity due to its origin and production process. The wide range of properties can even be expanded by appropriate post-processing steps. This flexibility can be used in so-called composite materials to achieve tailor-made material properties. In addition to the substitution of fossil carbon, which today is (still) indispensable in numerous industrial processes (carburizing of steel and cast materials, chemical industry, etc.), biogenic carbon can also open up new possibilities due to its diverse nature. In the workshop, possible applications of biochar as a material component will be presented on the example of current projects in the fields of plastic and concrete industry. The potential of biochar as a carbon-source in the material manufacturing industry, the necessary steps for its further development and undesirable developments, will be discussed with experts of the manufacturer and the user side.



11:00 **Welcome and Workshop-Introduction**
Stefan Martini, *BEST, GER*

Biochar and its properties as a component in composite materials
Marco Baratieri, *Free University of Bolzano, ITA*

Experiences in biochar-polymer composite production
Andrea Brunetin, *NADIR, ITA*

Dielectric properties of biochar, biochar-polymer composites and possible applications
Oliver Pischler, *Graz University of Technology, IHS, AUT*

Discussion

Introduction Green Carbon Lab
Elisabeth Wopienka, *BEST, AUT*

12:30 **Mittagspause**

Project presentation Alps4greenC – Implementation pathways for sustainable Green Carbon production
Konstantin Moser, *BEST, AUT*

Green concrete – from climate killer to climate saver
Axel Preuß, *CarStorCon Technologies, GER*

Electrically Conductive Biocomposites Based on PHBV and Wood-Derived Carbon Fillers
Christoph Unterweger, *Wood K plus, AUT*

Fuel cell membrane electrode assembly with green carbon support
Minoj Gnanaseelan*, FILK Freiberg Institute, GER

15:00 **End**

Workshop: Digitale Technologien in der Land- und Forstwirtschaft – Aktueller Stand und Ausblick

HBLFA Francisco Josephinum Wieselburg

Freitag 20. Jänner

Saal 9, 13:30 – 15:00

„Die Digitalisierung ist in aller Munde. Welche Anwendungen sind in der Praxis angekommen? Bei diesem Workshop wird versucht, darauf Antwort zu geben."

Chair: Josef Rathbauer, *HBLFA Francisco Josephinum, BLT Wieselburg, Österreich*

Die Digitalisierung spielt mittlerweile in allen Bereichen unseres Lebens eine Rolle. Ganz selbstverständlich wird das Smartphone für die Kommunikation, das Recherchieren und viele andere Anwendungen eingesetzt.

In der Land- und Forstwirtschaft sind digitale Technologien in verschiedenen Bereichen im Einsatz. So gibt es mittlerweile ausgeklügelte Systeme (Farmmanagementsysteme), die Daten der Bewirtschaftung von agrarischen Flächen und in der Tierhaltung aufnehmen und zur Dokumentation, zur ökonomischen Beurteilung und als Basis für das Management verfügbar machen.

Weitere Anwendungen sind die teilflächenspezifische Bewirtschaftung, die Abschätzung von Biomasseerträgen und der koordinierte Einsatz von Maschinen und Geräten.

13:30 Eröffnung durch **Josef Rathbauer**

15:00 **Ende**

Vortragssprache **Deutsch**

Workshop: Digital technologies in agriculture and forestry – current status and outlook

HBLFA Francisco Josephinum Wieselburg

Friday 20. January

Room 9, 13:30 – 15:00

„Everyone is talking about digitalization. Which applications have arrived in practice? This workshop will attempt to provide an answer to that."

Chair: Josef Rathbauer, *HBLFA Francisco Josephinum, BLT Wieselburg, AUT*

Digitalization is omnipresent in all areas of our lives. Smartphones are used totally naturally for communication, research and many other applications. In agriculture and forestry, digital technologies are used in various areas. Meanwhile there exist sophisticated systems (farm management systems) which process data from the cultivation of agricultural land and animal husbandry to make it available for documentation, for economic assessment and as a basis for management.

Other applications are section-specific farming, estimation of biomass yields and the coordinated use of machines and equipment.

13:30 Opening by **Josef Rathbauer**

15:00 **End**

Parallelblock 14

Herstellung, Veredelung und Nutzung von Biokohle und Biomasseaschen

Saal 6, 13:30 – 15:00

Chair: Elisabeth Wopienka, *BEST, AUT*

13:30 **Beginn**

Potenzial von Rostaschen aus der Verbrennung von Nicht-Holz-Biomasse als nachhaltigem zementartigem Zuschlagstoff
Hossein Beidaghy Dizaji, *DBFZ, DEU*

Pelletierqualität von Biokohlen: Einfluss von Karbonisierungsverfahren und Additiven
Niklas Illich, *BEA Institut für Bioenergie GmbH, AUT*

Green Carbon für Kunststoffverbundwerkstoffe
Stefan Martini, *BEST, AUT*

Reduktion von Emissionen, Bindung von Nährstoffen und Kohlenstoffsequestrierung durch die Lagerung von Gülle mit Beigabe von Biokohle aus der Holzvergasung
Lucas Schuchter, *MCI Management Center Innsbruck, AUT*

Low-Tech, CO2-negative Wärmeversorgung durch Pyrolyse von minderwertiger Biomasse und Bodenspeicherung von Biokohle
Tobias Pröll, *BOKU, AUT*

15:00 **Kaffeepause**

Vortragssprache **Englisch**

Workshop: Potenziale und Grenzen „grünen" Wachstums in der österr. forstbasierten Bioökonomie

Freitag **20.** Jänner

Saal 2, 13:30 – 15:00

Chairs: Raphael Asada, *Universität Graz, AUT*
Claudia Mair-Bauernfeind, *Universität Graz, AUT*
Tobias Stern, *Universität Graz, AUT*

Im europäischen Raum steht die Umgestaltung der Wirtschaft hin zu einer biobasierten Ökonomie auf der politischen Agenda. Die Europäische Kommission erwartet neben einer reduzierten Abhängigkeit von fossilen Ressourcen sowie geringeren Treibhausgasemissionen die Schaffung neuer Geschäftsmöglichkeiten und Impulse für Wirtschaft und Beschäftigung im ländlichen Raum.

Sechs Studierende der Umweltsystemwissenschaften (Universität Graz, TU Graz) widmeten sich ein Semester lang der Frage, welche ökonomischen Wachstumspotenziale und Grenzen die österreichische forstbasierte Bioökonomie aufweist. Hierzu wurden drei in Forschung und Politik genannte Entwicklungspfade genauer untersucht, die im Rahmen des Workshops diskutiert werden. Insbesondere wird erörtert, welche Rohstoff-, Effizienz- und Innovationspotenziale für den österreichischen waldbasierten Sektor bis 2040 bestehen und welche Hauptfaktoren den Beitrag dieser Potenziale zu „grünem" Wachstum beschränken.

Vortragssprache **Deutsch**

Parallel Session 14

Production, upgrading and use of green carbon and biomass ashes

Room 6, 13:30 – 15:00

Chair: Elisabeth Wopienka, *BEST, AUT*

13:30 **Opening**

Potential of bottom ashes from non-woody biomass combustion as sustainable supplementary cementitious materials
Hossein Beidaghy Dizaji, *DBFZ, GER*

Influence of carbonization process and additives on the quality of biochar pellets
Niklas Illich, *BEA Institut für Bioenergie GmbH, AUT*

Green Carbon for Polymer Composites
Stefan Martini, *BEST, AUT*

Emission reduction, nutrient retention and carbon sequestration in the storage of liquid manure with bio-char from wood gasification
Lucas Schuchter, *MCI Management Center Innsbruck, AUT*

Low-tech CO^2 negative emission district heating supply based on pyrolysis of low-value biomass and biochar soil storage
Tobias Pröll, *BOKU, AUT*

15:00 **Coffee Break & Poster Presentation**

Language **English**

Workshop: Potentials and limits of „green" growth in the Austrian forest-based bioeconomy

Friday **20.** January

Room 2, 13:30 – 15:00

Chairs: **Tobias Stern**, *University of Graz, AUT*
Claudia Mair-Bauernfeind, *University of Graz, AUT*
Raphael Asada, *University of Graz, AUT*

The transformation of the economy towards a biobased economy is on the political agenda in the European region. In addition to reduced dependence on fossil resources and lower greenhouse gas emissions, the European Commission expects the creation of new business opportunities and impulses for the economy and employment rate in rural areas.

Six students of Environmental Systems Science (University of Graz, Graz University of Technology) have examined the potentials and limitations of Austria's forest-based bioeconomy for one semester. Three development paths mentioned in research and policy were analyzed in great detail - their findings will be discussed in the workshop. In particular, the workshop discusses the existing raw material, efficiency and innovation potentials of the Austrian forest-based sector until 2040 and, moreover, main factors limit the contribution of these potentials to „green" growth.

Language **German**

Workshop: Digitalisierung in der Fernwärmeversorgung – durch Daten zu optimierten Systemen und neuen Geschäftsmöglichkeiten, Special Session organisiert von IEA DHC Annex TS4 Digitalisation of District Heating and Cooling Systems, Saal 7, 13:30 – 15:00

Freitag 20. Jänner

„Digitalisierung ist die Schlüsseltechnologie für die Transformation der (Fern-)Wärmeversorgung und für eine Integration großer Anteile von Wärme aus erneuerbaren Quellen in unser Energiesystem."

Chair: Dietrich Schmidt, *Fraunhofer IEE, DEU*

„Die zunehmende Digitalisierung ermöglicht einen deutlich effizienteren und flexibleren Betrieb von Fernwärmesystemen."

Co-Chair: Markus Gölles, *BEST, AUT*

13:30 Eröffnung

Die Integration digitaler Prozesse für einen optimierten Anlagenbetrieb und die effiziente Einbindung von erneuerbaren Energien in der Fernwärme
Dietrich Schmidt, *Fraunhofer IEE, DEU*

Ende-zu-Ende Optimierungssoftware für Fernwärmesysteme
Peter Ott, *Danfoss, AUT*

Chancen der Fernauslesung zur Netzoptimierung durch intelligente Nutzung von Daten
Hans Peter Gremel, *Kamstrup, AUT*

Digitalisierung von Übergabestationen in Fernwärmenetzen mit LoRaWan und Methoden für ein automatisiertes Monitoring und zur Reduktion von Rücklauftemperaturen von Wärmenetzen
Dirk Pietruschka, *HfT Stuttgart / University of Applied Science Stuttgart, DEU*

DistrictLab-H: Ein Werkzeug für die Unterstützung bei der Absenkung von Systemtemperaturen in Fernwärmesystemen
tba.

15:00 **Ende**

IEA DHC

Vortragssprache Englisch

Workshop: Digitalisation in District Heating Supply – with data to optimized systems and new business opportunities – Special Session organized by IEA DHC Annex TS4 Digitalisation of District Heating and Cooling Systems, Room 7, 13:30 – 15:00

Friday 20. January

„The main technology for modernizing our (central) heat supply and incorporating significant amounts of heat from renewable sources into our energy system is digitalization."

Chair: Dietrich Schmidt, *Fraunhofer IEE, GER*

„Increasing digitalization is allowing district heating systems to be operated more efficiently and flexibly."

Co-Chair: Markus Gölles, *BEST, AUT*

13:30 **Opening**

Integration of digital pocesses for optimised operation of and efficient inclusion of renewable heat sources into district heating
Dietrich Schmidt, *Fraunhofer IEE, GER*

End-to-end optimization software for district energy systems
Peter Ott, *Danfoss, AUT*

Remote readout as a chance for heating grid optimisation via intelligent use of data
Hans Peter Gremel, *Kamstrup, AUT*

Digitalization of transfer stations in heating networks with LoRaWAN and methods for automated operational monitoring and return temperature reduction
Dirk Pietruschka, *HfT Stuttgart / University of Applied Science Stuttgart, GER*

DistrictLab-H: a tool to support temperature reduction efforts in District Heating Systems
tba.

15:00 **End**

Language English

IEA DHC

Posterpräsentationen, Foyer

Im Rahmen der Posterpräsentation werden ausgewählte Konferenzbeiträge und Projekte zu folgenden Themenbereichen vorgestellt:

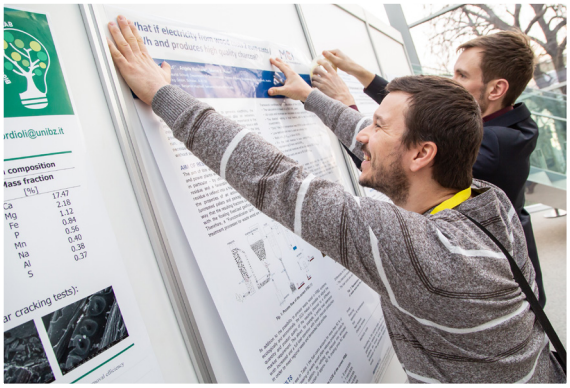
- **Bioökonomie**
- **Biogas**
- **Brennstoffcharakterisierung**
- **Wärme aus Biomasse und Verbrennungstechnologien**
- **Biomassepotenziale und Märkte**
- **Logistik und Lagerung**
- **Strom aus fester Biomasse**
- **Energiepflanzen und Reststoffe**
- **Brennstoff- und Substrataufbereitung**
- **Pellets**
- **Nachhaltigkeit**
- **Neue Absatzmärkte für Technologien**

Die Posterausstellung findet im **Foyer** zu den Tagungsräumen statt und ist während der beiden Vortragstage (19. und 20. Jänner 2023) zugänglich.

Darüber hinaus werden in den Konferenzpausen eigene **Postersessions** durchgeführt, in denen Ihnen die AutorInnen für Auskünfte zur Verfügung stehen.

Donnerstag 19. Jänner
10:30–11:00 Uhr
12:30–13:30 Uhr
15:00–15:30 Uhr

Freitag 20. Jänner
10:30–11:00 Uhr
12:30–13:30 Uhr
15:00–15:30 Uhr



Poster Presentations, Foyer

Selected conference contributions and projects will be presented within a poster presentation. The following topics will be presented in detail:

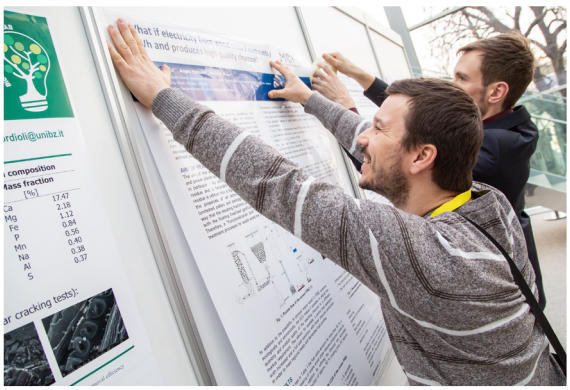
- **Bioeconomy**
- **Biogas**
- **Fuel characterization**
- **Biomass heat and combustion technologies**
- **Biomass potentials and markets**
- **Logistics and Storage**
- **Electricity from solid biomass**
- **Energy crops and Residues**
- **Fuel and substrate preparation**
- **Pellets**
- **Sustainability**
- **New markets for technologies**

The poster exhibition takes place in the foyer of the Messe Congress Graz and is accessible throughout the conference days (19th and 20th of January, 2023).

Furthermore, there will be guided poster sessions during the conference breaks, which enables the visitors of the conference to ask their questions to the scientists directly.

Thursday 19. January
10:30–11:00 Uhr
12:30–13:30 Uhr
15:00–15:30 Uhr

Friday 20. January
10:30–11:00 Uhr
12:30–13:30 Uhr
15:00–15:30 Uhr



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fröling besser heizen

SYNCRAFT Das Holzkraftwerk.

Bio Energie Kärnten

EGGER PowAir Cleaning

KWB

KOMPTECH Technology for a better environment

Energie Netze Steiermark – Ein Unternehmen der Energie Steiermark

STW Stadtwerke Klagenfurt

HARGASSNER Heiztechnik der Zukunft

Erneuerbare Energie ing. Leo Riebenbauer

bioenergie.at Ihr Plus in Wärme.

Austroflex Rohr-Isoliersysteme