Proceedings of the 1st Renewable Energy Sources - Research and Business conference

BOOK OF ABSTRACTS

June 22 - 24, 2016, Wrocław, Poland

ORGANISER

Wojciech Budzianowski Consulting Services

PATRONS

Wrocław University of Science and Technology

Polish Federation of Engineering Associations - NOT Wrocław Committee

Renewable Energy and Sustainable Development (RESD) Group

International Scientific Committee (ISC)
Tom Bruton (Ireland)
Wojciech Budzianowski - Chair (Poland)
Pascal Champagne (Canada)
Bin Chen (China)
Wei-Hsin Chen (Taiwan)
Aoife Foley (UK)
David Fulford (UK)
Paavo Pelkonen (Finland)
Anélie Pétrissans (France)

Scientific Advisory Board (SAB)
Mamdoh Al-Busoul (Jordan)
Nagaraj Banapurmath (India)
Andrea Bassi (Italy)
Anna Bryszewska-Mazurek (Poland)
Valentina Fortunato (Belgium)
Bartłomiej Igliński (Poland)
Wojciech Mazurek (Poland)
Jarosław Milewski (Poland)
Juliana Miranda Mitkiewicz (Portugal)
Karthikeyan Natarajan (Finland)
Abdul-Sattar Nizami (Saudi Arabia)
Alessandro Parente (Belgium)
Shireen Quereshi (India)
Christophe Wylock (Belgium)
Anas Zyadin (Finland)
Andrzej Żyromski (Poland)

Organising Committee
Wojciech Budzianowski - Chair
Wojciech Mazurek
Andrzej Żyromski

Conference Founder
Wojciech Budzianowski

Publisher
Wojciech Budzianowski Consulting Services

Editor
Wojciech Budzianowski

ISBN
978-83-948507-0-8

Scope

The **Renewable Energy Sources - Research and Business (RESRB) 2016** conference is designed as a platform for reporting, discussing, improving and disseminating recent developments in renewable energy science, technology and business. Participants from various organisations such as universities, institutes, NGOs, associations, industries etc. are invited. It is an international event with ambitions to share leading research expertise and facilitate business development and thus to be one of the most influential renewable energy knowledge transfer channels. The conference is a must for research groups at the cutting edge of renewable energy science, technology, policy and business development. Commercial business participants seeking innovations and expanding to new markets will be hosted. The conference will facilitate synergies between academia and commercial sectors. Delegates from enterprises may benefit from sponsoring, exhibiting and networking thus improve their business environment. RESRB 2016 is particularly focused on developed and developing countries applying green growth policies and plays the role in informing policymaking processes. The participation mode can be either in-person or virtual. Digital Proceedings will be made available to all participants including abstracts and contact details of all accepted contributions. Submitted manuscripts will be internally reviewed by RESRB international referees and review outcomes communicated to authors for facilitated publication in leading international journals and edited books.

Themes

The **RESRB 2016** conference focuses on five key areas: (1) bioenergy, (2) wind, (3) solar, (4) hydro and their (5) business development. The themes include:

- Bioenergy
- Solar photovoltaics
- Wind
- Hydro
- Solar thermal
- Concentrated solar power
- Geothermal energy
- Wave, tide and other marine energies
- Biofuels
- Renewable heating and cooling
- Renewables in transport
- Renewables in buildings
- Agricultural and land use issues
- Biomass production
- Agronomy
- Biorefineries
- Renewables in industrial symbiosis
- Energy systems
- Road maps
- Hydrogen and fuel cells
- Desalination
- Software tools
- Environmental impact
- Life cycle assessment
- Decarbonisation and synergies with fossil fuels
- Sustainability
- Standards
- Infrastructure
- Materials
- Resources
- Power system, power electronics, smart grid
- Micro scale renewables
- Power grids, requirements, international connections
- Grid stability, power generation flexibility
- Electric vehicles
- Energy storage
- Renewables in developed, developing and underdeveloped countries
- Business models and strategies
- Planning
- Renewable energy policy
- Renewable energy economics
- Renewable energy business development
- Innovations, intellectual property rights
- Financing, project finance and management
- Accounting
- Venture capital, entrepreneurial finance, corporate finance
- Intellectual property, start-ups, licensing
- Merger and acquisitions, capital markets, outsourcing, consumer behaviour,
- Incentives, legislation
- Energy markets
- Risks and risk management
- Costs and revenues

- Legislative and ethical considerations for research, business and policy interactions
- Societal issues, consumer access, social benefits
- Organisations
- Other topics of critical importance for the development of renewable energy science, technology, policy and business

Preface

The first RESRB 2016 conference aims at most important areas of renewable energy research and business. This first edition fills the gap existing in the current portfolio of international conferences by focusing on business aspects of renewable energy innovative research. The 1st RESRB 2016 brings together 84 authors (see Author index), participating either in-person or virtually. The total number of abstracts in the Proceedings is 32. Virtual participation enables to hear voices on renewable energy topics also from developing countries from where authors rarely can attend conferences in-person mainly from economic reasons. The conference model relying on combining in-person and virtual participations is innovative. It is very suitable for very busy people of the modern world and for people from developing countries where there is huge unexploited potential for harvesting renewable energy. RESRB 2016 may therefore have a real impact on science, technology and business, both in developed and developing countries.

Renewable energy sources are enormous and widely available in the world. Harvesting renewable energy and providing it to the society has the potential to accelerate sustainable economic growth and reduce poverty. The development of renewable energy sources is also considered as a crucial countermeasure to prolonged fossil fuels use and it can mitigate atmospheric greenhouse effect and global warming, thereby achieving energy and environmental sustainability.

There is a remarkable technological progress and renewable technology costs are decreasing year after year, especially for solar. However, without accounting for external project costs, some present-day renewable energy projects are often perceived risky and may cannot compete with the well-established fossil fuels industries. Therefore, research in academia and in companies can play an important role in order to develop innovative technological solutions that further reduce costs, improve project technical, economic and environmental performance as well as cause real impact in the society. It can be done through entrepreneurship initiatives. Innovative business models could act as a catalyst to foster applied cute-edge technologies created inside academia into the real world. In order to make it happen and introduce the new concept of creating real impact on society though science and technology, the RESRB conference was created. The mission of the RESRB conference is to be one of leading arenas of bringing creative solutions to the public and thus shortening the gap between their creation and their impact. The RESRB conference also targets at discussing of most adequate renewable energy business models that fit contexts in the

different parts of the world, including developed, developing and underdeveloped countries.

More specifically, the 1st RESRB 2016 put emphasis on different subjects such as:

- Improving value chain of biomass with intention to make it more sustainable, technically sound, economically viable and environmentally and socially beneficial;
- Highlighting progress in biomass and biowaste torrefaction, drying and anaerobic digestion, biofuel expansion, and hydrogen production and applications emphasising future relevance of these technologies for increased renewable energy uptake and contributing with new business relevant insights;
- Effective business models for utilising solar energy and bioenergy, e.g. by involving shared capital expenditures, integrating these sources with existing industries or engaging social capital.

Numerous others innovative technologies and businesses approaches were presented and discussed by conference participants. New important contributions of RESRB 2016 include: (i) renewable energy start-up company presentation emphasising how to efficiently engage social capital with social awareness, (ii) characteristics of business models and innovativeness of renewable energy projects in Africa, (iii) improved understanding of social aspects of biomass supply chain in Eastern Europe, (iv) renewable hydrogen separation advancements, (v) assessment of biomethane storage in serving integrated energy systems, (vi) identifying promising products and new technologies improving biorefining business feasibility as well as (vii) providing energy policy insights in the context of renewable energy supply and demand, economic growth and greenhouse gas emission mitigation.

The conference participants put emphasis on the role of biomass utilisation as mean for job creation in rural areas compared to stand-alone solar or hydro energy project which gives the biomass more economic credentials. The conference participants also stressed the need between industry, private companies, and stakeholders to form a polycentric approach that assist in de-risking renewable energy projects and overcome obstacles that may emerge prior or after projects being commissioned.

The 1st RESRB 2016 was very well received by all conference participants and was found as an essential element for improving innovative research and business thinking in renewable energy. RESRB 2016 facilitated networking and as an added-value created new social, academic and business related links

among many participants from different continents. Building upon this promising outcome, the 2nd RESRB will be organised very soon.
Overall, this 1st RESRB conference suggests that more attention needs to be put on business contexts of harvesting and using renewable energy sources. New knowledge and new applied solutions created by research need to involve business considerations from the very beginning which often is overlooked today. Policymaking processes should support integrated research and business renewable energy initiatives. Thus RESRB conference series could be an excellent platform for reporting, discussing, improving and disseminating most recent achievements in business relevant renewable energy science and technology.

W.M. Budzianowski,
W.H. Chen,
J. Miranda Mitkiewicz,
A. Zyadin

CONTENTS

W.M. Budzianowski, M. Brodacka

Short communications

Programme

Wednesday 22 June 2016	
12.00-22.00	Registration
12.00-14.00	Lunch break (Restaurant)
14.00-14.15	Opening session (Room A)
14.15-15.30	Short communication session 1 - Co-Chairs J. Miranda Mitkiewicz, A. Zyadin (Room A) RESRB2016.0016 - Biomass conservation using an optimized drying process for energy sorghum bagasse T. Iqbal, A.S. Nizami, S. Eckhoff, M.L.A. Barreto, Y. Sadef, M. Rehan, K. Shahzad RESRB2016.0017 - Study of sugar catalyst coating on various types of packing F.A. Lahin, J.A. Janaun, J.M. Tan, S. Abang RESRB2016.0018 - Catalytic conversion of residual lignocellulosic sugarcane bagasse into ethyl levulinate S. Quereshi, S. Dutta RESRB2016.0019 - Analysis of solar thermal energy utilization in an ORC system - a case study of Poland A. Bryszewska-Mazurek, W. Mazurek RESRB2016.0020 - Renewable energy in sustainable economic growth in Rwanda - Energy policy implications M. Rwema, W.M. Budzianowski
15.30-16.00	Coffee break (Hall and Room A)
16.00-17.00	Keynote lectures (Room A) RESRB2016.0002 - From a social challenge to a business opportunity - Wonderfuel case study J. Miranda Mitkiewicz*, M.D.P. Coelho. *speaking author at MIT Portugal Program/FEUP, Porto, Portugal RESRB2016.0003 - An overview of business models and innovativeness of potential renewable energy projects in Africa: a perspective from Pan African University students W.M. Budzianowski*, I.K. Nantongo, C. Abimana, E.O. Akumu, Y. Alokore, S.O. Babalola, M.L. Bachir, C. Bamutura, A.K.K. Gachuri, M.S. Hefney Diab, G. Ituze, Kiprono, G.C. Kouakou, T. Kukeera, M. Lyambai, W.B. Megne, R. Muceka, A. Mugumya, J.A. Mwongereza, O.V. Nwadiaru, M. Rwema, S. Sow. *speaking author at Wojciech Budzianowski Consulting Services, Wrocław, Poland
17.00-19.00	Oral session 1 - Chair W.-H. Chen (Room A) RESRB2016.0004 - Analysis of biomass supply chain in Poland: experiences from BEST Project, Finland P. Pelkonen, A. Zyadin RESRB2016.0005 - Modelling of mass loss kinetics of wood biomass during the torrefaction A. Pétrissans, M. Chaouch, M. Pétrissans RESRB2016.0006 - Power requirements of biogas upgrading by water scrubbing and biomethane compression: comparative analysis of various plant configurations W.M. Budzianowski, C.E. Wylock, P.A. Marciniak RESRB2016.0007 - Biowaste-to-energy in Poland

	B. Igliński, R. Buczkowski
19.00-20.00	ISC and SAB Meeting (Room A)
Thursday 23 June 2016	
08.00-09.00	Registration
09.00-09.15	Dissemination session (Room A)
09.15-10.00	Plenary lecture (Room A) RESRB2016.0001 - Progress in biomass torrefaction technology for upgrading solid fuels W.-H. Chen* *speaking author at National Cheng Kung University, Tainan, Taiwan
10.00-10.30	Coffee break (Hall and Room A)
10.30-13.00	Oral session 2 - Chair P. Pelkonen (Room A) RESRB2016.0008 - Numerical investigation of a flameless-based Stirling engine fed with LCV biogas V. Fortunato, F. D'Ambrosio, P. Wettrell, A. Parente RESRB2016.0009 - A novel design of a small scale solar-biogas hybrid system J. Miranda Mitkiewicz, A.I. Palmero Marrero, A. Coelho de Oliveira RESRB2016.0010 - High-value low-volume bioproducts coupled to bioenergies with potential to enhance business development of sustainable biorefineries W.M. Budzianowski RESRB2016.0011 - Environmental and economic conditions of giant *Miscanthus* productivity (*Miscanthus x giganteus*) at varied water availability A. Żyromski, W.M. Budzianowski, M. Biniak-Pieróg, M. Żyromski RESRB2016.0012 - Influence of biogas technological improvement and adoption rate on greenhouse gas emissions from primary energy: a scenario analysis for Poland until 2100 W.M. Budzianowski, B. Pakuła
13.00-14.00	Lunch break (Restaurant)
14.00-15.30	Oral session 3 - Chair A. Pétrissans (Room A) RESRB2016.0013 - External control strategy for Seasonal Thermal Energy Storage operation M. Wołowicz, J. Milewski, W. Bujalski, A. Szczęśniak RESRB2016.0014 - Hydrogen recovery characteristics in a multichannel palladium membrane system W.-H. Chen, C.-W. Tsai, Y.-L. Lin RESRB2016.0015 - Biomethane storage: evaluation of technologies, end uses, business models, and sustainability W.M. Budzianowski, M. Brodacka
15.30-16.00	Coffee break (Hall and Room A)
16.00-17.00	Short communication session 2 - Co-Chairs V. Fortunato, B. Igliński (Room A) RESRB2016.0021 - Development of algae biorefinery in Saudi Arabia: a source of bioenergy and bioproducts A.-S. Nizami, M. Rehan, K. Shahzad, I.M.I. Ismail RESRB2016.0022 - Development of models for energy policy analysis - Software requirements in African contexts W.M. Budzianowski, M. Lyambai, C. Bamutura, A. Mugumya, J.A. Mwongereza RESRB2016.0023 - Design of solar energy dryer for fruits in Jordan M. Al-Busoul

	RESRB2016.0024 - Decarboxylation-decarbonylation: a promising route for production of olefins and fuel range hydrocarbons from biorenewable resources S. Quereshi, E. Ahmad, W.M. Budzianowski, K.K. Pant, S. Dutta
17.00-18.00	Panel: Renewable energy technologies and business development (Room A) Invited panelists: W.-H. Chen, P. Pelkonen, J. Miranda Mitkiewicz, A. Zyadin, V. Fortunato, A. Pétrissans, K. Natarajan, W.M. Budzianowski (moderator)
18.00-21.00	Gala dinner (Room next to Restaurant)
Friday 24 June 2016	
09.00-11.00	Short communication session 3 - Co-Chairs A. Bryszewska-Mazurek, K. Postawa (Room A) RESRB2016.0025 - Using of gas-phase products at waste tyre pyrolysis as a fuel - opportunities and challenges: a review D. Czajczyńska, R. Krzyżyńska RESRB2016.0026 - Insights on catalytic production of commodity chemicals and light olefins from non-edible cottonseed oil Y. Agrawal, E. Ahmad, K.K. Pant RESRB2016.0027 - The impact of socio-economic indicators in assessing natural gas supply alternatives - Macedonian case D. Mladenovska, A.M. Lazarevska RESRB2016.0028 - Nanofluids for improving efficiency of photovoltaic (PV) modules M. Al-Busoul , A. Al Alawin, T. Abu Rahmeh, A. Ghrair, E. Saleh, B. Hatqawi, Y. Al Abdallat, S. Haddad RESRB2016.0029 - Thermoeconomic analysis of an ORC system cooperating with a condensation turbine A. Bryszewska-Mazurek, W. Mazurek RESRB2016.0030 - Enhancing low-carbon economic growth and renewable energy uptake in countries with per capita gross domestic product between 10 and 20 kUSD W.M. Budzianowski RESRB2016.0031 - Africa carbon emissions consequences and constraints to renewable energy deployment C. Bamutura, W.M. Budzianowski RESRB2016.0032 - Two-step anaerobic digestion: state of the art and modeling approaches K. Postawa, W.M. Budzianowski
11.00-11.15	Closing session (Room A)

BOOK OF ABSTRACTS

PLENARY LECTURES

RESRB2016.0001

Progress in biomass torrefaction technology for upgrading solid fuels

Wei-Hsin Chen*

*speaking author at National Cheng Kung University, Tainan, Taiwan

Department of Aeronautics and Astronautics, National Cheng Kung University, Tainan 701, Taiwan;
*corresponding author email: chenwh@mail.ncku.edu.tw

Abstract
Development of renewable energy is considered as an effective countermeasure for natural resource sustainability and climate change mitigation. Among developing renewable energy, biomass and bioenergy is the largest energy resources. Biomass can be transformed into gas or liquid fuels via a variety of methods, such as gasification, pyrolysis, anaerobic digestion, fermentation and transesterification. It can also be utilized as a solid fuel and burned directly for heat and power generation. However, biomass is characterized by its high moisture content, low calorific value, hygroscopic nature and large volume or low bulk density, which result in a low conversion efficiency as well as difficulty in the collection, grinding, storage and transportation of biomass. Torrefaction is a promising technology to upgrade biomass for solid fuel production. After undergoing torrefaction, the properties of biomass are improved to a great extent and close to those of coal. Consequently, torrefied biomass has a potential to replace coal consumed in industry. This talk addresses the important issues and progress in torrefaction technologies. The impact of torrefaction parameters, such as feedstock, temperature, duration, and carrier gas, on biomass properties will be emphasized. The challenge and potential topics deserving further investigation will be illustrated finally.

Keywords
biomass; torrefaction; solid fuel

Full paper
Chen WH, Peng JH, Bi XT. A state-of-the-art review of biomass torrefaction, densification and applications. Renewable and Sustainable Energy Reviews. 2015:44;847-866. https://doi.org/10.1016/j.rser.2014.12.039

KEYNOTE LECTURES

RESRB2016.0002

From a social challenge to a business opportunity - WonderFuel case study

Juliana Miranda Mitkiewicz[1,*], Mário Domingos Pires Coelho[1]

[*]speaking author at MIT Portugal Program/FEUP, Porto, Portugal

[1]MIT Portugal Program, FEUP, University of Porto, Porto, Portugal; [*]corresponding author email: up201407354@fe.up.pt

Abstract

The Promotion of Used Cooking Oil Recycling For Sustainable Biodiesel Production European Program, RecOil, states that approximately 40% of the population wrongly throw used cooking oil (UCO) in domestic sewers. Households generate more than 60% of the total amount of UCO in Portugal, stated Studies of the Portuguese Environment Agency. In this context, Portugal and Spain stand out as European leaders at the annual quantity of UCO generated per capita, with 8,34 kg and 27,92 kg respectively. Thus, it is estimated that annually more than 200,000 tons of used cooking oil are dumped in sewage systems in the Iberian Peninsula. Besides representing a major environmental problem and cost to operators of water and sewage networks, considering the market value of used cooking oil from 500 Euros per tonne and all non-recycled oil in Iberian Peninsula (400,000 tons), these numbers represent losses of 200 million euros per year. Both countries have mandatory biofuel quotas (7% in Portugal and 4.1% in Spain) in the composition of fuels supplying the road system. According to resolutions of the European Union, this figure should be 10% for all Member States in 2020, generating a demand for biofuels more than 5 million tons per year in this region. Currently, more than 90% of biofuels produced in the countries comes from imported oil/grains. The grains and oils commonly used for biofuel production are soybean oil, rapeseed and palm. In recent years, the value of ton of oil of these commodities varied between 400 and 1000 Euros. In addition, both countries have idle capacity of biofuel production. Thus, it identifies a major environmental problem as well as a huge market potential to be explored in used cooking oil generated in the domestic sector. In addition, a potential market related to the integrated management of the OAU in major producers of UCO and an opportunity to use the idle capacity of biodiesel production plants through UCO was identified. The WonderFuel Company arises from the opportunity and intention to solve a major social and environmental problem that the public and private sectors have not yet tackled. The business model was structured to act in schools in order to address the problem of the domestic sector ramification and the environmental education issues; and to fill the gap of idle capacity of biodiesel producers. The WonderFuel, a Social Enterprise, has its pilot project in high school in Porto, where was held workshops for young students and installed an oil collector. As a result, a considerable amount of UCO was collected in a three-month campaign. This result was encouraging and confirmed the company's expectations that a closer approach to citizens and families could generate more impact and return.

Keywords

biofuels; domestic sector; Iberian Peninsula; schools; used cooking oil, WonderFuel

This is confidential business material presented for the conference audience, will not be published.

RESRB2016.0003

An overview of business models and innovativeness of potential renewable energy projects in Africa: a perspective from Pan African University students

Wojciech M. Budzianowski[1,2,*], Irene K. Nantongo[2,3], Colette Abimana[3], Eric O. Akumu[3], Yunus Alokore[3], Samuel O. Babalola[3], Mohamed L. Bachir[3], Cleus Bamutura[2,3], Amon K.K. Gachuri[3], Mahmoud S. Hefney Diab[3], Gemma Ituze[3], Hillary Kiprono[3], Gnamien C. Kouakou[3], Tonny Kukeera[3], Martin Lyambai[3], Waffo B. Megne[3], Rolex Muceka[2,3], Andrew Mugumya[3], Jean d'Amour Mwongereza[3], Ogechi V. Nwadiaru[3], Michel Rwema[2,3], Salif Sow[3]

[*]speaking author at Wojciech Budzianowski Consulting Services, Wrocław, Poland

[1]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [2]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [3]Pan African University, B.P. 119, Pôle Chetouane, Tlemcen 13000, Algeria; [*]corresponding author email: wojciech.budzianowski@gmail.com; address: Poleska 11/37, 51-354 Wrocław, Poland

Abstract

This study provides an overview of innovative renewable energy projects proposed by Pan African University students. All descriptions of projects are systematically presented in uniformly formatted tables. Business models for all these projects are explained and discussed. Project innovativeness is expounded. Projects are synthesized and most promising are emphasized. Project reproducibility in other locations is discussed. Outlook for future investment opportunities in African contexts is given.

Keywords

project; renewable energy; business model; innovativeness; Africa; investment opportunity

Full paper

Budzianowski WM, Nantongo I, Bamutura C, Rwema M, Abimana C, Akumu EO, Alokore Y, Babalola SO, Gachuri AKK, Hefney Diab MS, Ituze G, Kiprono H, Kouakou GC, Kukeera T, Lyambai M, Megne WB, Muceka R, Mugumya A, Mwongereza JA, Nwadiaru OV, Sow S. An overview of business models and innovativeness of potential renewable energy projects in Africa: a perspective from Pan African University students. Renewable and Sustainable Energy Reviews

ORAL LECTURES

RESRB2016.0004

Analysis of biomass supply chain in Poland: experiences from BEST Project, Finland

Paavo Pelkonen[1,*], Anas Zyadin[1,*]

[1]School of Forest Sciences, University of Eastern Finland, P.O. Box 111, 80101, Finland; [*]corresponding author email: Paavo Pelkonen paavo.pelkonen@uef.fi, Anas Zyadin anas.zyadin@uef.fi

Abstract

Securing affordable and sustainable biomass supply chain is one of the main challenges to bioenergy development in countries such as Poland seeking to promote and increase the use of renewable energy resources. Poland is an agricultural country in Central Europe endowed with high biomass potentials (from agricultural, forestry operations and, industry, horticulture, and industrial and municipality solid wastes (MSW) that are deemed not fully utilized. The use of biomass in co-firing industry under the green certificate scheme has had varying consequences on the biomass market and the whole biomass supply chain and its stakeholders like, particularly on Polish farmers. Farmers' play pivotal role in securing constant and reliable biomass supply for energy production, therefore, their ability and willingness to engage in biomass procurement process need to be effectively studied.

We present results of the Poland related sub-project of The "Sustainable Bioenergy Solutions for Tomorrow" (BEST) research program. The program is coordinated by CLIC Innovation with funding from the Finnish Funding Agency for Innovation (TEKES). The core objective of the BEST is to create new, sustainable, clean, and innovative business opportunities based on effective utilization of renewable and bioenergy resources. Under the BEST project activities creating new bioenergy supply chain by conducting resources assessment, logistical calculations, and investigating the farmers' ability and willingness to supply surplus biomass for energy generation is a quintessential approach to ensure business feasibility on the short and long run.

In this presentation, we will share our experience in biomass supply chain and the overall bioenergy development prospects in Poland. This experience has accumulated during the BEST project (www.cleen.fi) carried out in two regions in Poland (Torun and Upper Silesia provinces).

Keywords

Poland; farmers; biomass; co-firing; policies and incentives

Full paper

Zyadin, A., Natarajan, K., Igliński, B., Iglińska, A., Kaczmarek, A., Kajdanek, J., Pappinen, A., Pelkonen, P. Farmers' willingness to supply biomass for energy generation: evidence from South and Central Poland. Biofuels 2016 https://doi.org/10.1080/17597269.2016.1225647

RESRB2016.0005

Modelling of mass loss kinetics of wood biomass during the torrefaction

A. Pétrissans[1,*], M. Chaouch[2], M. Pétrissans[1,*]

[1]Laboratoire d'Etudes et de Recherche sur le Matériau Bois, EA 4370-USC INRA, Université de Lorraine, Faculté des Sciences et Technologies, BP 70239, F-54506 Vandoeuvre-lès-Nancy, France; [2]Département de génie mécanique, École Polytechnique de Montréal, Montréal (Qc) H3C 3A7, Canada; [*]corresponding author email: anelie.petrissans@univ-lorraine.fr; mathieu.petrissans@univ-lorraine.fr

Abstract

Facing the decrease of fossil fuels resources, it becomes important to enhance the use of biomass as a source of energy. Wood biomass and forest residues offer a large source of renewable material and energy. However wood has viscous-elastic and plastic behaviours and its grinding requires a lot of energy. Torrefaction is a heat treatment process improving wood grindability [1], increasing the carbon content. It was shown that the energy balance between grinding energy gain, the increase of wood heat value and energy consumption for torrefaction is favourable [2].

Properties of torrefied biomass depend on mass loss. Hence, controlling the torrefaction process means to control precisely this parameter. The purpose of this study is to develop a numerical tool to predict the torrefaction mass loss. The mass loss kinetics for torrefaction of wood samples was studied using specially conceived equipment to measure mass losses during the heat treatment. A mathematical model for the kinetics of the thermodegradation process was used and validated. The mathematical formulation describing the simultaneous heat and mass transfers requires coupled nonlinear partial differential equations. These unsteady-state model equations were solved numerically by the commercial package COMSOL.

[1] Bergman PCA, Kiel JHA. Torrefaction for biomass upgrading. In: Sjunnesson L, Carrasco JE, Helm P, Grassi A, editors. Proc. 14th European Biomass Conference, Paris, France; 2005. p. 206–9.

[2] Prins MJ, Ptasinski KJ, Janssen FJJG. More efficient biomass gasification via torrefaction. Energy 2006;31:3458-70.

Keywords

Modelling; reaction kinetics; torrefaction; thermo-degradation; wood

Full paper

Pétrissans A, Gérardin P, Pétrissans M. Experimental investigation and numerical prediction of wood mass loss kinetics and carbon content evolution during the torrefaction. Maderas: Ciencia y Tecnologia

RESRB2016.0006

Power requirements of biogas upgrading by water scrubbing and biomethane compression: comparative analysis of various plant configurations

Wojciech M. Budzianowski[1,2,*], Christophe E. Wylock[3], Przemysław A. Marciniak[2]

[1]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [2]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [3]Université Libre de Bruxelles, Transfers, Interfaces and Processes (TIPs), Brussels, Belgium; [*]corresponding author email: wojciech.budzianowski@gmail.com

Abstract

Biogas upgrading by water scrubbing followed by biomethane compression is an environmentally benign process. It may be achieved using various plant configurations characterised by various power requirements with associated effects on biomethane sustainability. Therefore, the current study has been undertaken to systematically investigate the power requirements of a range of water scrubbing options. Two groups of water scrubbing are analysed: (1) high pressure water scrubbing (HPWS) and (2) near-atmospheric pressure water scrubbing (NAPWS). A water scrubbing plant model is constructed, experimentally validated and simulated for seven upgrading plant configurations. Simulation results show that the power requirement of biogas upgrading in HPWS plants is mainly associated with biogas compression. In contrast, in NAPWS plants the main power is required for water pumping. In both plants the compression of the biomethane from atmosphereic pressure to 20 MPa also contributes remarkably. It is observed that the lowest specific power requirement can be obtained for a NAPWS plant without water regeneration (0.24 kWh/Nm^3 raw biogas) but this plant requires cheap water supply, e.g. outlet water from a sewage treatment plant or river. The second is HPWS without flash (0.29 kWh/Nm^3 raw biogas). All other HPWS with flash and NAPWS with water regeneration plants have specific power requirements between 0.30 and 0.33 kWh/Nm^3 raw biogas. Biogas compression without upgrading requires about 0.29 kWh/Nm^3 raw biogas. The thermodynamic efficiency of biogas upgrading is between 2.2 and 9.8% depending on the plant configuration while biomethane compression efficiency is higher, about 55%. This result implies that the upgrading process has a remarkable potential for improvement whereas compression is very close to its thermodynamic limit. The potential for minimising energy dissipation in the state-of-the-art HPWS upgrading plant with flash by applying a rotary hydraulic pumping device is evaluated at about 0.036 kWh/Nm^3 raw biogas meaning the specific power requirement reduction of 10%.

Keywords

biogas; biomethane; water scrubbing; power requirements; thermodynamic efficiency; rotary hydraulic pumping device

Full paper

Budzianowski WM, Wylock CE, Marciniak PA. Power requirements of biogas upgrading by water scrubbing and biomethane compression: comparative analysis of various plant configurations. Energy Conversion and Management 2017;141:2-19. http://dx.doi.org/10.1016/j.enconman.2016.03.018

RESRB2016.0007

Biowaste-to-energy in Poland

Bartłomiej Igliński[1,*], Roman Buczkowski[1]

[1]Nicolaus Copernicus University in Toruń, Faculty of Chemistry, Gagarina 7, 87-100 Toruń, Poland; [*]corresponding author email: iglinski@chem.umk.pl

Abstract

The aim of this paper was to estimate the amount of waste biomass that could be obtained for energy purposes in Poland. It was assumed that waste biomass and production surplus should be utilised to a greater degree whilst fallows and uncultivated land should be managed. Liquid biofuels should be obtained from food surplus or from its waste (such as post-frying oil). Biogas could be obtained from animal droppings, biodegradable fractions of municipal waste and sewage sludge.

Bionergy could be obtained from the following sources: waste wood from forests and timber industry - 80.0 PJ, waste orchard biomass - 27.8 PJ, waste straw - 93.8 PJ, hay - 26.3 PJ of energy. It was assumed that if 50% of fallows and 25% of uncultivated land was used for energy purposes, then it would be possible to obtain 51.7 PJ of energy from common osier (*Salix viminalis)* biomass. Utilising food surplus to produce biofuels generate 1042.9 million dm^3 of bioethanol (16.4 PJ) and 227.2 million dm^3 RME (7.6 PJ). Animal droppings in Poland could generate 1818.0 million m^3 of biogas (30.1 PJ), municipal waste - 81.3 million m^3 (1.3 PJ) of biogas, sewage sludge - 26.0 million m^3 of biogas (0.4 PJ).

Power generation from biomass, especially from waste biomass, directly reduces the environmental pollution. The installations using renewable energy sources in Poland are local ones and do not require a centralised technological infrastructure. As small and dispersed technologies, they are naturally linked to the policy, strategy and development plans of the European Union.

Keywords

Energy; biowaste; biomass; biofuel; biogas; Poland

RESRB2016.0008

Numerical investigation of a flameless-based Stirling engine fed with LCV biogas

V. Fortunato[1,*], F. D'Ambrosio[1], P. Wettrell[2], A. Parente[1]

[1]Service d'Aéro-Thermo-Mécanique, Université Libre de Bruxelles, Bruxelles, Belgium; [2]Cleanergy AB, Therese Svenssons gata 15, SE-41755, Gothenburg, Sweden; [*]corresponding author email: valentina.fortunato@ulb.ac.be

Abstract

Nowadays, in the field of energy production, particular attention must be paid to improving efficiency and reducing pollutants. Cogeneration systems based on Stirling cycles appear particularly appealing to this goal, as they ensure high efficiency, fuel flexibility, low emissions, low noise/vibration levels and good performance at partial load. Moreover it is possible to couple such engines with flameless burners. Flameless combustion is a rather new technology that provides high efficiency in fuel consumption with low NO and soot emissions. It requires the reactants to be preheated above their self-ignition temperature and enough inert combustion products to be entrained in the reaction region, in order to dilute the flame. As a result, the temperature field is more uniform than in traditional non-premixed combustion systems, and it does not show high temperature peaks. Hence, NO formation is suppressed as well as soot formation, due to the lean conditions, low temperatures and the large CO_2 concentration in the exhausts. The increasing interest in flameless combustion is motivated by the large fuel flexibility, representing a promising technology for low-calorific value fuels, high-calorific industrial wastes as well as in presence of hydrogen. Recently several studies showed also the compatibility of such regime with biogas.

The growing trend today is that combustors should be fuel flexible. These different fuels are typically of Low Caloric Value (LCV), such as biofuels, syngas and landfill mixtures. The industrial company Cleanergy provides energy solutions based on the Stirling engine. Cleanergy currently focuses on renewable, gaseous mixtures that are relatively difficult to burn since the energy content is small compared to natural gas. One such gas is Landfill gas. In a landfill gas extraction the methane content is decaying with time.

The objective of the present study is the numerical investigation of such a system via different CFD software, namely Ansys Fluent and OpenFOAM. Due to the specific features of the flameless combustion regime, particular attention must be paid to the choice of the physical models, especially the turbulence-chemistry interaction model. Another key parameter is the choice of the kinetic mechanism (to which extent they can be reduced it is still an open issue) and the pathways for the pollutant formation (different routes become more relevant than the traditional ones).

Keywords

Stirling engine; biogas

RESRB2016.0009

A novel design of a small scale solar-biogas hybrid energy system

Juliana Miranda Mitkiewicz[1,*], Ana Isabel Palmero Marrero[1], Armando Coelho de Oliveira[1]

[1]FEUP, University of Porto, Porto, Portugal; [*]corresponding author email: up201407354@fe.up.pt

Abstract

According to the latest report from the World Health Organization in 2015, 2.4 billion live without adequate sanitation. Additionally, the 2014 World Energy Outlook data stated that 1.3 billion people has still no access to electricity and 2.7 billion people rely on traditional use of biomass for cooking, which causes several problems, including air pollution and respiratory diseases. Disadvantaged people are the most likely group to suffer from climate change, according to the IPCC Report of 2014. A Hybrid Energy System (HES) can play an important role to tackle not only the Global Warming problems but also the basic needs of this group, such as sanitation and energy poverty. This study discusses on design and development of a novel small-scale solar-biogas hybrid energy system, its conversion technologies and its social and environmental benefits. The hybrid system has been designed as a cost-effective community shared solar-biogas micro-combined heat and power scheme to enable utilization within the physical and socio-economic reality of disadvantaged areas. This system intends to serve as a stand-alone, 100% renewable energy, solar-biogas power system, for small communities demands, where it will deliver heat, electricity, and at the same time provide a solution for the sewage and organic waste produced. An optimal system-operating mode is obtained by using a biogas storage system in order to ensure the reliability of the HES. The digestion system is feed with different types of organic waste generated from the sewage system, kitchen and other perishable wastes produced locally by the community. The benefits of using locally produced biogas to drive a backup engine and the biogas storage system, in comparison to using a diesel engine as backup and batteries have been explored. This hybrid system has also been compared with the HES best practices presented in this paper. The results show that the solar-biogas hybrid system integrated with the biogas engine and the biogas storage system can be a better solution than using a diesel engine as backup. The HES is a commercial solution easy to deploy, install and maintain and its design is flexible to meet every demand. The diversities of these two energy primary sources make the system self-sufficient, cost effective and exclude the need of batteries and unsustainable resources. In terms of social and environmental benefits, the biodigester system will provide a very nutritious organic fertilizer, which can be used in crops or as a product to generate income for the community. Furthermore, the HES places a value on certain types of waste that currently, in addition to not being utilized properly, pose a serious problem for society.

Keywords

biogas; electricity, heat, hybrid energy system; renewable energy sources; sanitation; solar energy; storage system

RESRB2016.0010

High-value low-volume bioproducts coupled to bioenergies with potential to enhance business development of sustainable biorefineries

Wojciech M. Budzianowski[1,2,*]

[1]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [2]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [*]corresponding author email: wojciech.budzianowski@gmail.com; address: Poleska 11/37, 51-354 Wrocław, Poland

Abstract

Economically feasible production of conventional bioenergies such as biofuels, biopower and bioheat is a challenge in biorefineries because they have to compete with inexpensive fossil fuel energies while external production costs are rarely included into the present-day policies. Biomass consists of unique complex chemical structures that cannot be easily artificially synthesized and may be beneficially employed in various practical applications. Therefore, strategies relying on complete biomass disintegration through combustion, gasification or fermentation only to simple usable bioenergies do not lead to optimal utilization of biomass feedstock. Instead, cascading approaches are required in order to maximize biomass valorization. Consequently, high-value low-volume bioproducts coupled to bioenergies with potential to improve economic viability of biorefineries and biomass resource utilization are urgently required. Integrated production of bioenergies and bioproducts may be achieved by coupling existing biofuel plants with new bioindustries, by retrofitting existing bioindustries with new bioenergy facilities or by erecting completely new integrated facilities.

The current paper reviews literature and provides systematized insights into various high-value low-volume bioproducts coupled to bioenergies in biorefinery contexts. It analyses potential benefits of a range of such bioproducts and gives comments on associated business development. The review thus creates foundations for more thoughtful design procedures of economically feasible sustainable biorefineries that could meet technical and market requirements and improve cascading biomass utilization. Owing to insufficient technology readiness the study also aims at improved understanding of major technological gaps limiting expanded economically viable utilization of high-value bioproducts through biorefineries. It is emphasized that the major advantage of biorefineries is their suitability for maximizing valorization of structural and energetic potentials lying in biomass. The study suggests that new business models introducing high-value bioproducts to biorefineries are essential for achieving economic viability of industries within bioeconomy.

Keywords

biorefinery; bioproduct; bioenergy; business development; market; technology

Full paper

Budzianowski WM. High-value low-volume bioproducts coupled to bioenergies with potential to enhance business development of sustainable biorefineries. Renewable and Sustainable Energy Reviews 2017;70:793-804. http://dx.doi.org/10.1016/j.rser.2016.11.260

RESRB2016.0011

Environmental and economic conditions of giant Miscanthus productivity (Miscanthus x giganteus) at varied water availability

Andrzej Żyromski[1,*], Wojciech M. Budzianowski[2,3], Małgorzata Biniak-Pieróg[1], Marcin Żyromski[4]

[1]Institute of Environmental Protection and Development, Wrocław University of Environmental and Life Sciences, Wrocław, Poland; [2]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [3]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [4]Department of Crop Production, Wrocław University of Environmental and Life Sciences, Wrocław, Poland; [*]corresponding author email: a.zyromski@gmail.com

Abstract

Biomass, which is one of the renewable energy sources for years is of interest both from a cognitive, environmental and economic aspects. Among other energy crops giant *Miscanthus* grass is of interest due to its properties. Its biomass can be universally used as well as biofuel or components in all kinds of industries. As a perennial grass it does not require complicated cultivation and harvesting while providing high yields of about 20 tons d.m./ha. It has a high calorific value at about 18 MJ/kg. However, like all plants, is sensitive to water deficits during the vegetation period, resulting in a reduction of the productivity. Therefore, over the years many research centers has developed methods of varying complexity in order to assess the amount of energy crops biomass during their growing season. Every time those models require a lot of good quality and hard to acquire input data. Considering this, the Authors decided to identify how the periodic or permanent water deficiency, which is one of the most important problems, may reduce the productivity of giant *Miscanthus*. To assess the formulated problem, the results of biometric measurements of giant *Miscanthus* and the information about precipitation from the growing season were used. The experiment was conducted in the Agro and Hydrometeorology Observatory belonging to the Wrocław University of Environmental and Life Sciences, located in south-western part of Poland. Field measurements used in the study were carried out in the years 2011-2015. These included the period from the 2nd to the 6th year of extensive cultivation of this plant. Giant *Miscanthus* cultivation was carried out in two variants. In the first one the plants could freely make use of water through capillary rise from the groundwater level. In the second one the plants were grown in the soil evaporimeters and could only use water from precipitation due to the lack of contact with ground water. Both variants reflect the conditions that exist in the natural environment. The following years of field experiment were characterized by different precipitation and thermal conditions as well as the levels of groundwater. For this reason the possibility of using rainwater in the years of the experiment was rated in respect to a long 50-year period of observations.

Comparative analysis of the results of both variants in the years of experiment showed that water deficiency can reduce significantly the productivity of giant *Miscanthus.* Simultaneously the analysis based on the results of the biometric measurements show a statistically significant correlation between the growth of *Miscanthus* in both adopted variants. Obtained dependence allow to estimate the reduction of biomass for areas with deep groundwater levels, and so there is no possibility of replenishment of precipitation through the capillary rise. Obtaining a comparable level of productivity can be achieved through the application of irrigation, which significantly increases the cost of biomass production. The relation between the dynamic growth of biomass and precipitation and air thermal conditions during the growing season is also of a high statistical significance level.

Keywords

Miscanthus; water availability; agrobiomass

RESRB2016.0012

Influence of biogas technological improvement and adoption rate on greenhouse gas emissions from primary energy: a scenario analysis for Poland until 2100

Wojciech M. Budzianowski[1,2,3,*], Bartosz Pakuła[3]

[1]Wrocław University of Science and Technology, Wrocław, Poland; [2]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [3]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [*]corresponding author email: wojciech.budzianowski@gmail.com

Abstract

Greenhouse gas (GHG) emissions can be reduced by displacing fossil fuels by renewable energy, especially if life cycle GHG footprint of these newly introduced renewables is sufficiently low and Energy Return on Invested (ERoI) is high. Bioenergy harvesting relies on biomass cultivation which alleviates GHG footprint but has complex production and processing chains which in turn increase GHG footprint. The complex bioenergy production and processing chains also adversely affect ERoI, which is relatively low, typically between 1 and 7, much lower than for large scale hydro for example. Therefore, the development of bioenergy technologies toward low life cycle GHG footprint and high ERoI is essential, if bioenergy is to be seriously considered as a truly sustainable renewable energy option.

This study investigates the influence of biogas technological improvement and adoption rate on GHG emissions from energy. To this aim a scenario analysis for Poland until 2100 is carried out. Life cycle GHG footprint and ERoI of biogas are calculated accounting for state-of the-art and biogas technology and emerging technologies that may be deployed in next decades. The main findings reveal that today the size of the biogas energy sector is too small to be able to remarkably reduce GHG emissions of a European country like Poland. However, in next few decades, along with increased biogas production capacity and technological progress, this influence might be meaningful. In the long run, e.g. in 2100, assuming alleviated GHG footprint of the national mix only scenarios with high technological advancements and deep penetration of biogas may reduce GHG footprint. The study emphasises that with ongoing GHG footprint reduction of national mixes also renewable technologies such as biogas will require reduced life cycle GHG footprint which may be challenging given their complex technological chains.

Keywords

greenhouse gas; life cycle assessment; energy mix; biogas adoption rate; technological improvement; Poland

Full paper

Budzianowski WM. Influence of technological improvement and adoption rate of biogas industry on greenhouse gas footprint of the energy system of Poland between 2000 and 2100. International Journal of Energy Technology and Policy 2018

RESRB2016.0013

External control strategy for Seasonal Thermal Energy Storage operation

Marcin Wołowicz[1,*], Jarosław Milewski[1], Wojciech Bujalski[1], Arkadiusz Szczęśniak[1]

[1]Institute of Heat Engineering, Warsaw University of Technology, Warsaw, Poland; *corresponding author email: marcin.wolowicz@itc.pw.edu.pl

Abstract

The paper presents the results of using an external control strategy to optimize seasonal thermal energy storage (STES). Literature studies have been carried out related to design and optimization of STES. Two STES configurations were taken into account with adequate constraints. The objective function was defined as minimum operating costs of the entire system. A structural external strategy is proposed which optimizes all heat flows based on the simplex method (Solver(R)). Simulations of system operation were carried out with and without the proposed external strategy for randomly generated outside temperatures in a 5 year horizon.

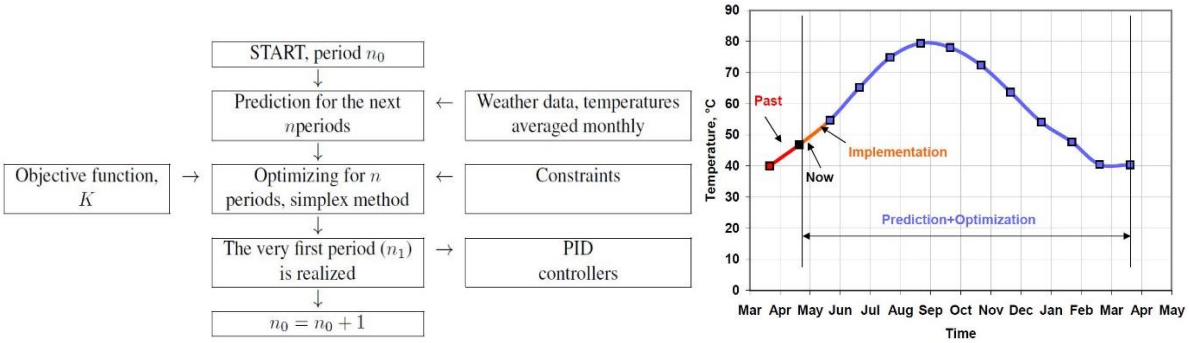


Fig. 1. An example of utilization of the optimizing algorithm

An external control strategy and optimizing algorithms are proposed for supporting the STES operation. The operating costs of systems with smaller sized devices (solar collectors by 41%, and water tank volume by 45%) are two times smaller than for the bigger sized system. Profits from utilization of the external control strategy are relatively small, at the level of 4..5%. Apart from economic profits, using the proposed external control strategy lowers the maximum heat produced by the natural gas boiler in the range 3..18%. Use of an external control strategy does not provide spectacular profits, but theoretically a huge water tank can be run without any control system merely by applying a simple regulation system. Short-term dynamic behaviour of the STES system is not analysed here, but can have an important impact on the obtained results. It should also be noted that there are other methods for the control approach to complex systems, including a bio-inspired solution.

Keywords

STES; heat management; dynamic simulation; control strategy

RESRB2016.0014

Hydrogen recovery characteristics in a multichannel palladium membrane system

Wei-Hsin Chen[1,*], Ching-Wei Tsai[1], Yu-Li Lin[2]

[1]Department of Aeronautics and Astronautics, National Cheng Kung University, Tainan 701, Taiwan; [2]Energy and Environmental Laboratories, Industrial Technology Research Institute, Hsinchu 310, Taiwan; [*]corresponding author email: chenwh@mail.ncku.edu.tw

Abstract

A multichannel palladium (Pd) membrane system in association with flow bypass is designed for hydrogen separation with high recovery, and the mass transfer phenomena in the system are simulated by developing a computational fluid dynamics (CFD) model. Two Pd membranes are installed in the system. The predictions suggest that the H2 recovery (HR) can be improved by flow bypass significantly. The higher the Reynolds number of the feed gas, the more pronounced the improvement of the bypass. The HR by the first membrane is independent of the bypass ratio (BR), revealing that the enhancement of HR is completely contributed by the second membrane. An increase in H2/CO2 molar ratio in the feed gas reduces HR, but raises the H2 permeation rate. The maximum HR by the second membrane always develops at the feed gas Reynolds number (Rer,M1) of 500, regardless of bypass ratio. This reveals that the aforementioned Reynolds number is an appropriate condition for H2 separation in the present membrane system. Based on the HR in the absence of flow bypass (i.e., BR=0), the higher the Rer,M1, the larger the intensification of H2 permeation.

Keywords

hydrogen; palladium membrane

Full paper

Chen WH, Tsai CW, Lin YL. Numerical studies of the influences of bypass on hydrogen separation in a multichannel Pd membrane system. Renewable Energy. 2017:104;259-270. https://doi.org/10.1016/j.renene.2016.12.032

RESRB2016.0015

Biomethane storage: evaluation of technologies, end uses, business models, and sustainability

Wojciech M. Budzianowski[1,2,3,*], Marlena Brodacka[3]

[1]Wrocław University of Science and Technology, Wrocław, Poland; [2]Wojciech Budzianowski Consulting Services, Wocław, Poland; [3]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [*]corresponding author email: wojciech.budzianowski@gmail.com

Abstract

Biomethane is a renewable gas that can be turned into dispatchable resource through applying storage techniques. The storage enables the discharge of stored biomethane at any time and place it is needed as gas turbine power, low carbon heat or transport fuel. Thus the stored biomethane could more efficiently serve various energy applications in the transport, power, and industrial sectors.

This work provides an overview and evaluation of biomethane storage technologies, end uses, business models and sustainability. It is shown that technologies are versatile, have different costs and efficiencies and may serve different end uses. Business models may be selected to fit to the regional specificities, realistic demands for storage related services, and the level of subsidies. By applying storage sustainability of biomethane is greatly improved in terms of economic viability, environmental impacts and social benefits. Stored biomethane may greatly facilitate adoption of intermittent renewable energy sources such as solar and wind. The findings show that biomethane storage needs to be combined with grid services or other measures to reduce overall costs must be involved. Discussions of this important business consideration are presented covering technology, end use, business model and sustainability.

Keywords

biomethane; storage; technology; end use; business model; sustainability

Full paper

Budzianowski WM, Brodacka M. Biomethane storage: evaluation of technologies, end uses, business models, and sustainability. Energy Conversion and Management 2017;141:254-273
http://dx.doi.org/10.1016/j.enconman.2016.08.071

SHORT COMMUNICATIONS

RESRB2016.0016

Biomass conservation using an optimized drying process for energy sorghum bagasse

T. Iqbal[1], A.S. Nizami[2], S. Eckhoff[3], M.L.A. Barreto[4], Y. Sadef[5], M. Rehan[2], K. Shahzad[2,*]

[1]Department of Process and Food Engineering, Faculty of Engineering, University of Putra, Selangor, Malaysia; [2]Center of Excellence in Environmental Studies (CEES), King Abdulaziz University, Jeddah, Saudi Arabia; [3]Department of Agricultural and Biological Engineering and Energy Bioscience Institute, University of Illinois at Urbana-Champaign, Illinois 61810, USA; [4]Department of Chemistry, Federal University of Vicosa, Vicosa, MG 36570-000, Brazil; [5]College of Earth & Environmental Sciences, University of the Punjab, Lahore, Pakistan; [*]corresponding author email: shahzadkhu@gmail.com

Abstract

Sorghum bagasse in recent years has emerged as a promising feedstock for production of biofuel and value-added products following various biological conversion pathways. However, adequate conservation is critical for utilizing sorghum bagasse as feedstock for fuel and fiber around the year in biofuels plants. The biomass conservation using drying method depends on different parameters such as energy efficiency, heat integration, emission control and dryer performance. The pressure drop phenomenon in drying systems for biomass conservation has been reported in few studies only. Therefore, this study aims to investigate the pressure drop as a function of airflow velocity and construct Shedd's curves for energy sorghum bagasse with an ambition to develop large-scale drying systems for biomass conservation. The bagasse was obtained by extracting the juice from the harvested sorghum and passing it through a juicing machine. The bagasse was manually chopped and stored on a wooden platform having 2.44 m^2 area in a 55 gallon drum at a depth of 0.57 m. A fan equipped with a regulator to control variable speed was attached to the plenum, having ability to generate airflow upto 2.15 ms^{-1}. The airflow velocities (0.24 to 1.32 ms^{-1}) caused pressure drop (9.96 to 346.23 Pa) across the empty drum. Similarly, the pressure drop in the drum containing sorghum bagasse ranged from 19.92 to 263.25 Pa due to airflow velocities ranging from 0.043 to 0.799 ms^{-1}, respectively. Pressure drop increased with increasing airflow velocity, and was similar to the pressure drop values for ear and shelled corn, reported in ASABE standards. Shedd's curves for sorghum bagasse samples were developed; these curves could be used for designing large-scale aeration systems for chopped energy sorghum.

Keywords

energy sorghum bagasse; airflow velocity; pressure drop; drying plenum; Shedd's curves

Full paper

Iqbal T, Nizami AS, Eckhoff S, Barreto MLA, Sadef Y, Rehan M, Budzianowski WM, Ouda OKM, Shahzad K. Biomass conservation using an optimised drying process for energy Sorghum Bagasse. Renewable Energy Focus 2017 http://dx.doi.org/10.1016/j.ref.2017.03.005

RESRB2016.0017

Study of sugar catalyst coating on various types of packing

F. A. Lahin[1,*], J. A. Janaun[2], J. M. Tan[2], S. Abang[2]

[1]Membrane Technology Research Group, Centre of Materials and Minerals, Faculty of Engineering, Universiti Malaysia Sabah, Jalan UMS, Sabah, MALAYSIA; [2]Catalysis, Reaction Engineering & Drying Technology Research (CREDYT), Faculty of Engineering, University Malaysia Sabah, 88400, Kota Kinabalu, Sabah, MALAYSIA; [*]corresponding author email: farhana.abdlahin@ums.edu.my

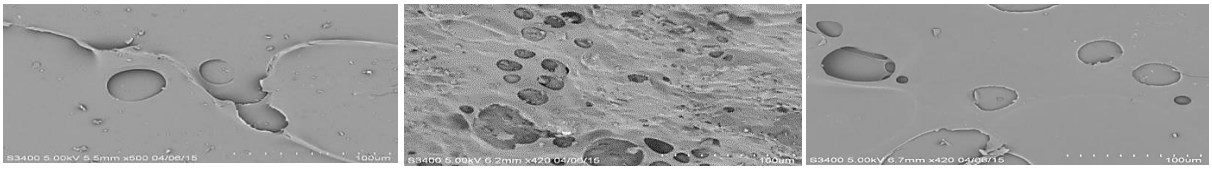
Abstract

Application of sugar catalyst in transesterification of biodiesel production has shown excellent catalytic performance especially for low quality feedstock. However, its limitation such as low specific surface area can cause complication in the process such as filtration difficulty for slurry phase operation and pressure drop due to low volumetric catalyst load and poor radial mixing in a packed bed reactor.

An increased surface area per unit volume and particle size of sugar will provide and interesting solution for these issues. Therefore in this research, a novel structured carbon-based acid catalyst was prepared through the deposit of the carbon precursor onto glass, ceramic and aluminum supports via dip-coating method. 65 wt% of d-glucose solution was used as the dip-coating solvent to prepare the structured carbon precursor. Carbonization process was followed to convert the d-glucose layer into black carbon char in an inert environment at 400 °C for hours with continuous nitrogen purging. $–SO_3H$ group was then introduced in the framework of the carbon char by multiple vapor phase sulfonation for 3 times. Four different carbonization methods were carried out (dry pyrolysis and hydrothermal carbonization with or without pressurization) in catalyst preparation.

Samples prepared from non-pressurized dry pyrolysis process showed strong acidity due to high adsorption of the acid group on the catalyst surface although the catalyst attached onto the support was the least compared to other preparation methods. Among the catalyst samples, the sulfonated carbon-based catalyst attached on the ceramic support showed the highest acidity (1.327 ± 0.034 mmol/g), followed by the catalyst deposited on the glass (0.917 ± 0.02 mmol/g) and aluminum support (0.321 ± 0.01 mmol/g). This is due to the porous structure of ceramic surface which allowed better interaction between reactants and SO_3H site in the carbon bulk. The FT-IR analysis shows that functional groups of -COOH, -OH, and $-SO_3H$ are present in the active sites of the catalysts.

Figure 1 shows the SEM analysis for Si-SC, Ce-SC and Al-SC samples. The sulfonated carbon-based catalyst deposit on ceramic support has rougher surface and higher porosity compared to other samples which suggest direct relation to the higher total acidity as more $–SO_3H$ group was introduced on the catalyst surface and the surface of the inner pore. The surface area of all samples were larger than 1 m^2/g, and having macroporous pore size of an average of more than 50 mm. TGA and DTA data shows the samples possess high thermal stability as there were less than 10% of weight loss within 400 °C.



(a) (b) (c)

Fig. 1. SEM Images of (a) Si-SC, (b) Ce-SC, and (c) Al-SC at Magnification of 500x for 100 µm.

The approach of using catalyst support from commercial materials to increase surface area has been proved to potentially improve catalytic processes using acid catalyst with increase of active sites.

However, further studies on adhesion method onto catalyst support should be researched to optimize the catalyst packing per unit area.

Keywords
structured sulfonated carbon-base acid catalyst; sugar catalyst; catalyst support; carbonization; multiple phase vapor sulfonation

RESRB2016.0018

Catalytic conversion of residual lignocellulosic sugarcane bagasse into ethyl levulinate

Shireen Quereshi[1,2], Wojciech M. Budzianowski[2,3], Suman Dutta[1,*], Tarun Kumar Naiya[4]

[1]Department of Chemical Engineering, Indian School of Mines, Dhanbad-826004, Jharkhand, India; [2]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [3]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [4]Department of Petroleum Engineering, Indian School of Mines, Dhanbad-826004, India; [*]corresponding author email: ss.dutta@hotmail.com

Abstract

Biofuel has emerged as an immense replacement of conventional fuel resources. Particularly, production of ethyl levulinate (EL) from biorenewable feedstock is an interesting area of research that has gained considerable attention of policy makers and scientists around the world. EL is reported to have excellent fuel blending properties and applications in chemical process industries. On the contrary, efficient utilization of residual lignocellulosic sugarcane bagasse (RLB) to generate electricity vis-à-vis chemicals is under debate. RLB essentially consists of 40-45% cellulose, 27-28% hemicellulose, 27% lignin and balance several other constituents which are combusted altogether during co-generation albeit, lignin contains 40% of total RLB energy content. Therefore, a better approach could have been development of an integrated technology which allows both the production of fuel/chemicals from cellulose as well as electricity via cogeneration of balance part.

In the present study, we have explored the catalytic conversion of RLB into EL in the presence of Brønsted as well as Lewis acids such as sulphuric acid (H_2SO_4), p-toluene sulfonic acid (p-TSA), aluminium chloride ($AlCl_3$) and chromium chloride ($CrCl_3$). Experiments were performed at atmospheric pressure and at a temperature range of 100°C-130°C in batch reactor setup. The catalysts concentration and reaction time was varied to study the effect on RLB conversion and EL selectivity. Obtained liquid products were analysed using GC-FID, GC-MS, FT-IR and ^{1}H NMR whereas residual solid product was characterized using XRD and CHNS. Based on ^{1}H NMR and GC-MS results, a plausible reaction mechanism was developed to correlate the catalytic properties and the products as well as the key intermediates obtained.

Initial screening of catalysts suggests that Brønsted acidity may be the determining factor for RLB conversion into EL. Highest EL yield was measured with sulphuric acid having strong Brønsted acidity. p-TSA and $CrCl_3$ were found to be least active for RLB conversion. However, considerable EL yield was obtained with $AlCl_3$ which essentially dictates the existence of other parameters that affects RLB conversion and EL selectivity besides nature of acidities of the catalysts. In addition, EL yield was found to be increasing with increase in temperature and reaction time. Moreover, same trend was followed when acid concentrations were increased. Under optimum conditions, 27.62% theoretical EL yield has been obtained at 130°C in the presence of 0.66M H_2SO_4 in 60 minutes of reaction time. In a separate study, we have studied the effect of Bronsted vs Lewis acidity effect and observed that an optimum combination of both the acidities is required to produce EL from RLB. Furthermore, residual solid product, containing majority of energy possessing lignin, can be potentially used for cogeneration process to produce electricity. Successful implementation of RLB conversion technologies is expected to affect lives of 55 million peoples positively in India alone who are directly or indirectly related with sugar industries.

Keywords

ethyl levulinate; biofuel; ethoxymethylfurfural; biomass conversion; catalysis

RESRB2016.0019

Analysis of solar thermal energy utilization in ORC system - case study for Poland

Anna Bryszewska-Mazurek[1,*], Wojciech Mazurek[1]

[1]Faculty of Environmental Engineering, Wrocław University of Science and Technology, Wrocław, Poland; [*]corresponding author email: anna.bryszewska-mazurek@pwr.edu.pl

Abstract

The paper presents analysis of Organic Rankine Cycle (ORC) micro-power plant (1 kWe) supplied by thermal energy from solar collectors. The ORC systems can recover low-grade heat and give possibility to be implemented in decentralized power plants. ORC systems are one of the promising method to combine heat and power production (CHP) utilizing renewable energy sources (solar thermal, geothermal heat) or low-temperature waste heat.

Two types of solar collectors were considered: plate solar collector and vacuum solar collector. Basing on the standardized climate data for Poland, the solar thermal energy potential was estimated for considered solar collectors (south direction, solar collector inclination 30^o). The calculations were performed establishing the working fluid temperature in ORC in a range of 70-90^{o}C, so the temperatures demanded from solar thermal heat source were in a range of 75-95^{o}C. Calculations covered six warm months from April to September.

The following results were got: the monthly average solar collector efficiency, solar thermal energy gain, unit solar collector area needed to supply the selected ORC system. Because of the relatively high temperature needed, the average annular efficiencies of considered solar collectors were rather low (for plate collectors it was approx. 15-30%, for vacuum collector: 30-40%). These low efficiencies influence the relatively high collector area demand (4-9m^2/kW - according to the hot water temperature). Annular solar thermal energy suitable for the ORC system was about 12-27 kWh/m^2 for the plate collector and 45-54 kWh/m^2 for the vacuum one (according to the hot water temperature).

The paper considers only basic ORC system with main components: evaporator, expansion machine (micro-turbine), condenser (air-cooled) and circulating pump. ORC working fluid is R245fa - HFC dry organic fluid in subcritical cycle (working temperature: 90-70^{o}C, working pressure: 10,1-6,1 bar). From calculations, the expected ORC efficiency (5,4-10,2%) was obtained, according to the inlet temperature range (70-90^{o}C), condenser cooling conditions (30-40^{o}C) and isentropic expansion. Taking into account the results have been got, the better solution is the vacuum solar collector as a heat source for ORC system then the plate one.

Keywords

solar thermal energy; solar collector; organic Rankine cycle; CHP system; renewable energy

RESRB2016.0020

Renewable energy in sustainable economic growth of Rwanda: energy policy implications

Rwema Michel[1,*], Wojciech M. Budzianowski[2,3,*]

[1]Energy Sciences, Pan African University Institute of Water and Energy Science PAUWES, Tlemcen, Algeria; [2]Wojciech Budzianowski Consulting Services, Wroclaw, Poland; [3]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [*]corresponding author email: michel@aims-cameroon.org; wojciech.budzianowski@gmail.com

Abstract

Over the last 10 years more than 70% Rwandese lives without access to electricity. Over 90% Rwandese in rural areas relies on biomass for cooking and lighting. It is truly that most of the energy sources are available within the country range from biomass up to Hydro. Today, biomass still dominate the energy source with 85%. Hydro power cover 60% in total installed capacity. Source like solar seem to be new technology in Rwanda, only few institutions are relying on solar energy. In 2015, solar feed into grid 8 MW. Geothermal, also is another sources which hold potential in energy sector in the region. Rwanda is among the riparian of rift valley which means that it can be a good opportunity for the country to benefit from geothermal, but currently it remains unexploited source the same case for Wind. In this article, we presented and discussed on current energy situation in Rwanda, stressing more about the state of renewable energy in Rwanda economic growth and energy policy implication. We have find that the high growth of renewable energy sources has occurred within the period of first EDPRS (2008-2012) and second EDPRS (2013-2018) due to the measures taken and strategy for development of energy sector.

Keywords

energy; biomass; renewable energy; energy policy

Full paper

Rwema M, Budzianowski WM. Renewable energy in sustainable economic growth of Rwanda: energy policy implications. International Journal of Energy Technology and Policy 2018

RESRB2016.0021

Development of algae biorefinery in Saudi Arabia: a source of bioenergy and bioproducts

Abdul-Sattar Nizami[1,*], Mohammad Rehan[1], Khurram Shahzad[1], Iqbal M. I. Ismail[1]

[1]Center of Excellence in Environmental Studies (CEES), King Abdulaziz University, Jeddah, Saudi Arabia;
[*]corresponding author email: nizami_pk@yahoo.com

Abstract

The current electricity demand of Kingdom of Saudi Arabia (KSA) is around 55 GW, which is projected to reach up to 120 GW by 2032. This energy is mainly produced from fossil fuels, posing a serious risk to human health and environment. Moving towards a sustainable model, KSA government has initiated a plan called King Abdullah City of Atomic and Renewable Energy (KACARE) to utilize the indigenous renewable energy resources to generate a further 54 GW energy from solar, wind, nuclear, geothermal and waste-to-energy (WTE). The arid nature of the KSA increases the importance of water in daily life and makes the country the third-largest per capita water user worldwide. There are about 12 thousand industries working in different sectors, which produce large quantities of wastes and waste sludge on daily basis. It has been estimated that 2.4 and 0.77 billion m3/ year of municipal and industrial wastewater respectively is produced in KSA, totalling to 3.17 billion m3/ year. Therefore, there is a huge potential of producing bioenergy and bioproducts, if this wastewater is treated in algae biorefinery. Algae as a 'natural chemical factory' has gained significant attention to produce several energy carriers, including starches for alcohols, lipids for diesel fuel, and bio-hydrogen (H2) for fuel cells and valuable materials and chemicals. A considerable progress has been made in recent years to optimize the production of energy and value-added products by utilizing algae under algae biorefinery concept. Biorefinery is a multi-process and multi-product system, similar to petroleum refinery. It utilizes various feedstock to produce useful materials, chemicals and bioenergy in the form of fuel, power and heat in an integrated system. Algae contains natural oils, carbohydrates and proteins for the production of biodiesel, ethanol and H2. The leftover or residues of algae after oil extraction can be digested anaerobically to produce methane (CH4) as an energy carrier. Furthermore, the AD digestate can be a source of animal feed and organic fertilizer. Although, theoretically algae can produce various fuels, an array of valuable materials and capture carbon emissions, but in practice profitable algal biofuel production has proven to be quite challenging. Most of these challenges lie in algae production methods, including selection of suitable algae strain, its cultivation, harvesting and extraction of value-added materials for energy and bioproducts along with their conversion pathways. The aim of this paper is to review the potential of algae biorefinery in KSA for the treatment of wastewater and production of bioenergy and bioproducts.

Keywords

algae; biorefinery; bioenergy

RESRB2016.0022

Development of models for energy policy analysis - Software requirements in African contexts

Wojciech M. Budzianowski[1,2,*], Martin Lyambai[3], , Eric O. Akumu[3], Cleus Bamutura[3], , Andrew Mugumya[3], Jean d'Amour Mwongereza[3]

[1]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [2]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [3]Pan African University Institute of Water and Energy Science (PAUWES) Tlemcen University, B.P. 119, Pole Chetouane, Tlemcen 1300, Algeria; [*]corresponding author email: wojciech.budzianowski@gmail.com; address: Poleska 11/37, 51-354 Wrocław

Abstract

Africa is faced with most challenging situation of access to clean energy as compared to its abundant energy resource. This situation has been static despite massive development in energy projects. The population without access to energy is still growing. Initial development of energy projects in Africa especially for electricity generation has not been based on economic development consideration but to achieve social and political objectives for certain individuals.

On an overview, Africa lacks energy models for policy analysis and this has limited the way the energy sector has been operating. Vast amount of energy resources coupled with better policy formulation will influence the development of energy projects in Africa. Much priority have been given to development of models for conventional energy projects but with a lot of limitation to renewable energy projects. Hybrid models such as HOMER software and MARKAL-TIMES have been widely applied in many parts of Africa.

As much as energy modelling in Africa has been used, its capabilities to address the long term Africa energy challenge has been unsuccessful. This calls for different modelling and simulation tools so as to project Africa energy situation and as well take the rightful decisions. The roles and applications of various modelling approaches is to improve the usefulness of energy policy in public decision making. Africa has numerous energy initiatives aimed to overcome its energy problems however, insufficient data on resources is affecting the development of energy modelling. The African Union Commission came up with the African Energy Commission (AFREC) that maps out energy policies, strategies, and development plans basing on the sub-regional, regional, and continental development priorities. AFREC also works with the ministries of energy of African countries through the Conference of Energy Ministers of Africa in coordinating policies and strategies with regards to electric power in Africa. For successful energy modelling in Africa, development of these modelling tools and scenarios should ensure a more technically, economically efficient, environmentally sound, climate-friendly, and socially responsible energy scenarios for supply and demand of energy for both grid and off grid in rural and urban setup. Therefore energy models for policy analysis should be adaptive to the African context and new ones developed on the African scenario.

Keywords: energy; policy analysis; modelling; software

RESRB2016.0023

Design of solar energy dryer for fruits in Jordan

Mamdoh Al-Busoul[1,*]

[1]Department of Mechanical Engineering, Faculty of Engineering Technology, Al Balqa' Applied University, Amman, Jordan; [*]corresponding author email: m_al_busoul@yahoo.com

Abstract

A natural convection solar dryer is to be designed to dry fruit slices, this work will describe the design considerations that will have to be followed and will present the calculation results of the design parameters, such as minimal solar collector area which is required to dry a batch of 100 KG sliced fruits in 16 hours (two days drying period) during the months of April to June. The final moisture content of the product will approximately be 10% whereas the initial moisture content is about 85%, for fruits (i.e. apples, bananas, etc.). The objective of this work is to design a solar natural convection dryer for drying apple slices. A solar dryer design was based on the producer described by Ampratwum, D.B. (1998). for drying dates (a cabinet type) and procedure described by Basunia, M. A. and Abe .T. (2001). for drying rough rice (natural convection a mixed-mode type). The size of the dryer was determined based on preliminary investigation which was found to be 2.6kg per m^2 (tray loading). The sample thickness is 3mm of apple slices. The following points were considered in the design of the natural convection solar dryer system:

a- The amount of moisture to be removed from a given quantity of wet mango.
b- Harvesting period during which the drying is needed.
c- The daily sunshine hours for the selection of the total drying time.
d- The quantity of air needed for drying.
e- Daily solar radiation to determine energy received by the dryer per day.
f- Wind speed for the calculation of air vent dimensions

The drying temperature was established as a function of the maximum limit of temperature the fruit might support. From the climatic data (Jordan metrological department, Amman, Jordan 2007) the average day temperature in April is 21.18ºC and RH is 40%. with daily global solar radiation incident on inclined surface of about 21.954 MJ/m2.day, density of air about 1.18 Kg/m3 and average wind speed in Amman centre equals 1.5 m/s. From the psychometric chart the humidity ratio is 0.0062kg H_2O/kg dry air. The optimal drying temperature was 70ºC and final moisture content of apple for storage is 10% wet basis. The corresponding relative humidity is 51% (sorption isotherms equation). The results of this work are as follows:

1-The surface area of the solar collector was calculated to be 24 m^2
2-The surface area of the air vent was calculated to be 0.067 m^2

The designed solar dryer with a collector surface area of 24 m2 is expected to dry (100 kgs of fresh sliced apple) with an initial moisture content of 85% to a moisture content of 10% wet basis in two days under ambient conditions during harvesting period of April to June.

This work is related to the subject of solar thermal and agricultural and land use issues.

Keywords

solar dryer; fruits drying; convection; design; radiation

Acknowledgments

This work has been carried out during sabbatical leave granted to the author (Dr.Mamdoh Al-Busoul) from Al-Balqa Applied University(BAU) during the academic year 2015/2016.

Full paper

Al-Busoul M. Design of fruits solar energy dryer under climatic conditions in Jordan. Journal of Power and Energy Engineering 2017:5;123-137. http://dx.doi.org/10.4236/jpee.2017.52007

RESRB2016.0024

Decarboxylation-decarbonylation: a promising route for production of olefins and fuel range hydrocarbons from biorenewable resources

Shireen Quereshi[1], Ejaz Ahmad[2], Wojciech M. Budzianowski[3,4], K.K. Pant[2], Suman Dutta[1,*]

[1]Department of Chemical Engineering, Indian School of Mines, Dhanbad-826004, India; [2]Department of Chemical Engineering, Indian Institute of Technology Delhi, New Delhi-110016, India; [3]Wojciech Budzianowski Consulting Services, Poleska 11/37, 51-354 Wrocław, Poland; [4]Renewable Energy and Sustainable Development (RESD) Group, Poleska 11/37, 51-354 Wrocław, Poland; [*]corresponding author email: ss.dutta@hotmail.com

Abstract

Sudden decline in crude oil prices and economic challenges associated with high temperature biofuel production technologies has slowed down biomass conversion related research across the world. Therefore, it is essential to explore techno-economically feasible alternative pathways for efficient utilization of biomass resources. In this regard, production of olefins and fuel range hydrocarbons from renewable biomass sources via decarboxylation-decarbonylation (DCO) reaction routes is an emerging area of research. Thus, in this review we illustrate various aspects of DCO route to develop sustainable technologies for production of fuels and value added chemicals from biomass derived substrates. Albeit, it is still debated whether decarboxylation route dominates or decarbonylation route dominates in DCO reaction, the ultimate objective to produce olefins and fuel range hydrocarbons is achieved via progressive removal of oxygen in the presence of an acid catalyst. Thus, role of acid catalysts, catalyst support, stability, and operating parameters on overall conversion and desired product selectivity has been discussed. Albeit, it is difficult to compare catalyst properties and activity due to different reaction conditions and techniques, attempt has been made to present a more generalized approach towards understanding of catalysts role into the production of olefins and linear chain alkanes via DCO route. In addition, effect of reaction environment, carbon-carbon chain length and degree of un-saturation in feedstock has been explored. Thereafter, discussion has been directed towards challenges and opportunities in production of olefins and fuel range hydrocarbons via DCO route and concluded with future scope of work.

Keywords

decarboxylation; decarbonylation; olefin; fuel

RESRB2016.0025

Using of gas-phase products at waste tyre pyrolysis as a fuel - opportunities and challenges: a review

Dina Czajczyńska[1,*], Renata Krzyżyńska[2]

[1]Faculty of Environmental Engineering, Wrocław University of Science and Technology, Wrocław, Poland; [2]Faculty of Environmental Engineering, Wrocław University of Science and Technology, Wrocław, Poland; [*]corresponding author email: dina.czajczynska@pwr.edu.pl

Abstract

Scrap tyres are one of the very burdensome kind of waste. Because of their purpose they must be chemically and mechanically resistant so after usage they become a waste, which is difficult to dispose. Almost 1.5 billion of tyres are produced each year, and finally every one and each of them join the waste stream. According the European Union regulations waste tyres cannot be stored. They should be recovered and recycled. Pyrolysis allows to dissolve the waste problem, but also offers obtaining useful products. In this process gas-, liquid- and solid-phase are formed. The obtaining gases poses well properties - chemical composition and high heating value - which makes them a valuable gas fuel. The amount of energy obtained from combustion of the gas-phase is enough not only to perform the pyrolysis process but also to be uses for other purposes. However, is appearing a challenge. The concentration of SO_2 in the flue gases is over the maximum allowed limit. Similar situation also could concern HCl, TOC and NO_X. In order to that it is necessarily to propose a gas cleaning method adapted to removing those substances from the exhaust gases formed in the waste tires pyrolysis installations.

Keywords

pyrolysis; waste tyres; pyrolytic gas; gas cleaning

Full paper

Czajczyńska D, Krzyżyńska K, Jouhara H, Spencer N. Use of pyrolytic gas from waste tire as a fuel: a review. Energy 2017 https://doi.org/10.1016/j.energy.2017.05.042

RESRB2016.0026

Insights on catalytic production of commodity chemicals and light olefins from non-edible cottonseed oil

Yashi Agrawal[1], Ejaz Ahmad[1], K.K. Pant[1,*]

[1]Catalytic Reaction Engineering Laboratory, Department of Chemical Engineering, Indian Institute of Technology, New Delhi-110016, India; [*]corresponding author email: kkpant@chemical.iitd.ac.in

Abstract

Growing chemical demand and unprecedented depletion of conventional fossil fuels is considered to be major cause of environmental and political concerns around the world. However, discovery of shale gas and technological improvements for its efficient utilization has lowered the possibilities of energy crisis. Albeit availability of feedstock for commodity chemicals vis-à-vis petrochemicals remains a challenge, thereby, causing a paradigm shift in the renewable and sustainable energy research from biofuel to essential commodity chemicals and light olefins. Most recent attempts has been made to produce linear alpha olefins (LAO), a replacement of fossil fuel based basic petrochemicals, which may serve as a feedstock for chemical process industries to manufacture a wide range of end product and consumer chemicals such as in the formulation of detergents, paints, rubber, and polymers. Moreover, avoiding conflict with the food industry, LAO obtained from non-edible oils may serve as a building block unit for key end product petrochemicals production, which holds a great societal and economic impact.

In present study, production of linear olefins have been explored *via* synthesis and application of inexpensive lanthanum catalyst supported over zeolites. In general, strong acidic sites of zeolite favours rapid cracking of feedstock leading to low LAO yield and coke deposition whereas catalysts containing low acidity are not suited for deoxygenation reaction process due to several undesired side reaction that takes place simultaneously. Thus, decreasing overall selectivity towards to desired LAO. On the contrary, impregnation of Lanthanum over zeolite surface lowers the strong acidic effects leading formation of medium acidic sites which are considered to be favourable for decarbonylation reaction to yield LAO. A fixed bed continuous reactor, equipped necessary instruments and accessories, was employed to study the LAO production from non-edible cottonseed oil in the presence of La-HZSM-5 at a temperature range of 300^{o}C-600^{o}C. Thereafter, obtained liquid and gaseous products were analysed using GC-FID, GC-TCD, GC-MS, ^{1}H NMR and ^{13}C NMR techniques whereas catalysts characterization and deactivation studies were performed using XRD, BET surface analyser, TPx, DSC-TGA and FT-IR.

Thereafter, effect of feed composition such as saturated and unsaturated model fatty acids, cottonseed oil and catalyst properties such as method of preparation, metal loading, surface area, acidity, support and thermal stability was studied. In general, higher olefin selectivity was measured at elevated temperatures and carbon chain length was observed to be a function of degree of unsaturation of feed stock. Major gaseous products of the reaction include propylene, ethylene, carbon mono-oxide, methane and hydrogen. Under optimum conditions 36% LAO yield was obtained at 500^{o}C in the presence of 6wt% La-HZSM-5. In addition, higher carbon chain length LAO and aromatics were detected in liquid product.

Keywords

light olefins; La-HZSM-5; cracking; decarbonylation; heterogeneous catalysis

RESRB2016.0027

The impact of socio-economic indicators in assessing natural gas supply alternatives - Macedonian case

Daniela Mladenovska[1,*], Ana M. Lazarevska[2]

[1]JSC Macedonian Power Plants, Skopje, Macedonia; [2]Faculty of Mechanical Engineering, Ss Cyril and Methodius University, Skopje, Macedonia; [*]corresponding author email: dmladenovska@gmail.com

Abstract

Introduction: Sustainable energy planning and supply have great importance in creating energy policies towards reliable energy systems, sound energy security and wellbeing of any nation. Thus, in accomplishing those targets decision makers have to consider numerous criteria and constraints. When defining a sustainability-paradigm-based decision-making frame, the economic aspects are the most crucial ones, while the social very often are marginalized. In the final project investment value, external costs originating from and related to environmental hazards and/or e.g. the turmoil in the quality of life caused by the energy related investment, can often prevail over the economic costs.

Objectives: Numerous studies show that Western Balkans is the region holding the biggest share of the old technology of coal-fired thermal power plants, implying significant air pollution, lower quality of life and higher costs for the national health protection systems. In Macedonia, energy production is mainly coal based, but the depletion of coal resources requires urgent action towards stable energy sources for reliable energy production. In terms of environmental and social benefits, natural gas can be pointed out as a solid option. Since Macedonia has no domestic natural gas production, implying that gas supply is fully sourced from Russia, its position regarding security of supply is quite vulnerable. Natural gas supply diversification will imply market and price competitiveness, resulting in improving quality of life (social aspects), accompanied by positive economic influences (investment environment).

Methodology: Herein, Multi Criteria Decision Making (MCDM) theory was used to combine both aspects - economic and social -, including criteria, relevant indicators and their weights in assessing natural gas supply alternatives in Macedonia. Analytical Hierarchy Process (AHP) was used to define problem hierarchy, while a corresponding questionnaire was prepared and filled out by a selected pool of experts, reflecting their pair-wise preferences among indicators. The herein presented approach is utilized for the first time to conduct such analyses to assess natural gas supply options for the Macedonian case.

Results: The survey among the pool of selected stakeholders resulted in calculated weights of each indicator. Although as a result of the survey, the economic set of indicators had the highest, while the social indicators had the lowest importance, it was interesting to analyze their common influence over the decision making process.

Conclusions: Six alternatives (natural gas supply options) including the existing pipeline have been assessed (ranked) versus each of the above mentioned indicators. The herein presented concept can be used as a tool for country policy makers in describing optimal natural gas supply chain challenges and opportunities.

Keywords

Multi Criteria Decision Making; Analytical Hierarchy Process; natural gas; economic indicators; social indicators

Full paper

Mladenovska D, Lazarevska AM. The impact of socio-economic indicators in assessing natural gas supply alternatives - Macedonian case.

RESRB2016.0028

Nanofluids for improving efficiency of photovoltaic (PV) modules

Mamdoh Al-Busoul[1,*], Aiman Al Alawin[1,*], Taieseer Abu Rahmeh[1,*], Ayoup Ghrair[2,*], Emad Addin Saleh[1,*], Bahaa Hatqawi[1,*], Yousef Al Abdallat[1,*], Shehadeh Haddad[1,*]

[1]Department of Mechanical Engineering, Faculty of Engineering, Al Balqa' Applied University, Jordan; [2]Royal Scientific Society, Jordan; [*]corresponding author email: m_al_busoul@yahoo.com, aalawin@yahoo.com, abu_rahmeh68@yahoo.com, ayoub.ghrair@rss.jo, eng.emadsaleh18@gmail.com, bahmahhat@gmail.com, Yousef_3bdallat@yahoo.com, shadihaddad40@gmail.com

Abstract

In this experimental study a PV panel was cooled using different cooling mediator, namely nanofluids comprising 0.02 %wt Al_2O_3 in water, 0.02 %wt and 0.04 %wt TiO_2 in water. The performance of the PV panels with the proposed cooling systems was investigated.

The apparatuses of the proposed systems were fitted on the roof of Mechanical Engineering Department/Faculty of Engineering Technology/Markeh/Amman /Jordan to ensure that all modules are working under the same operating conditions (solar irradiance intensity, atmospheric temperature, wind speed, and the dust content in the atmosphere). Experimental set up is simply composed of: the PV module that is to be cooled, a pump to circulate the cooling medium in the case of water and nanofluids, and a tank that is employed as accumulator and 6 mm copper tube network as a heat exchanger.

It has been observed that the performance of a solar module with water and nanofluid cooling is better than that without cooling. It has been found that the percent increases in the yielded electricity of the PV modules cooled by 0.02 %wt Al_2O_3, 0.02 %wt TiO_2, 0.04 %wt TiO_2 in water compared with that without cooling are 5.88, 4.42, 5.59, and 2.52, respectively.

Based on the obtained experimental data, the electrical efficiency is found to be improved by cooling PV panels with nanofluids. The best improvement exhibited when Al_2O_3 nanofluid was employed as cooling moderator. Moreover, it was found that increasing the concentration of the nanoparticles causes an improvement in both the yielded output power and the module's efficiency.

Keywords

photovoltaic module; nanofluid; cooling; efficiency

Full paper

Al-Busoul M, Al Alawin A, Abu Rahmeh T, Ghrair A, Saleh EA, Hatqawi B, Al Abdallat Y, Haddad S. Experimental investigation on cooling PV modules using nanofluids. Journal of Power Technologies 2018

RESRB2016.0029

Thermoeconomic analysis of ORC system cooperating with a condensation turbine

Anna Bryszewska-Mazurek[1,*], Wojciech Mazurek[1]

[1]Faculty of Environmental Engineering, Wrocław University of Science and Technology, Wrocław, Poland; [*]corresponding author email: anna.bryszewska-mazurek@pwr.edu.pl

Abstract

An organic Rankine cycle (ORC) operates the same principle as a steam Rankine cycle, but with a lower operating temperature and pressure. It is the result of using an organic working fluid instead of water. The ORC can be used in conjunction with a steam Rankine cycle to recover waste heat and improve overall system efficiency. The paper presents analysis of organic Rankine cycle (ORC) cooperating with cogeneration steam power plant. The ORC unit can utilize the waste heat from the condensation turbine vent to produce additional electricity, when the heat consumption in district heating system is lower than heat supply. The condensation turbine with a power of 4 MWe has the steam vent with the capacity of 7 t/h and steam pressure of 5 bar. The steam leaving the turbine heats the hot water in district heating system. However variable heating demands influence the electricity production in the turbine and decreases its efficiency. The purpose of the ORC unit is to develop the excess energy, assuming the steady steam flow through the vent and consequently the steady steam flow through the turbine. There are two options of installing the evaporator in the considered power plant: on the steam side or on the hot water side (on the district heat supply pipe). Three cascade working ORC units will be installed (each 250 kWe) to match variable waste heat demand. The working fluid in all ORC units is R245fa. The ORC condensers will be air-cooled so the minimum working fluid temperature is about 40^{o}C. The turbine inlet temperature is 150^{o}C when the evaporator is heated directly with a vent steam and then the efficiency of the cycle is about 13 %. When the evaporator is installed on the hot water side, the turbine inlet temperature is about 120^{o}C and then the efficiency of the cycle is about 11 %. Calculations of considered system indicate that it is technically feasible and profitable. Its payback period is about 6 years.

Keywords

organic Rankine cycle; CHP system; waste heat recovery; thermo-economic analysis

RESRB2016.0030

Enhancing low-carbon economic growth and renewable energy uptake in countries with per capita gross domestic product between 10 and 20 kUSD

Wojciech M. Budzianowski[1,2]

[1]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [2]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; *corresponding author email: wojciech.budzianowski@gmail.com

Abstract

The study investigates how countries with per capita gross domestic product between 10 and 20 kUSD (further referred to as middle-income countries) should shape domestic economies to enhance low-carbon economic growth and how low-carbon transition can be eventually turned to opportunity. It analyses relationships between CO_2 emissions and income for 138 countries obtained by applying regression analysis. Climate policy is configured by using a set of key low-carbon technologies and affordable assets fitting middle-income countries. It is complemented by the proposed enabling business environment including economic, societal, regulatory and political enablers. Middle-income countries need climate policies that can enhance resilient economic growth. The objectives of such climate policies may rely on creating low-carbon economy and turning towards renewable natural capital. By making right technologies/assets choices and reducing system costs middle-income countries will be able to deliver affordable energy thus driving industrialisation and enhancing economic growth. The proposed economic instruments will remove the obstacles associated with high interest rates and thus greater investments in capital intensive renewables will be facilitated. Overall, the proposed next economy system will trigger transition to low-carbon economy. The paper can be used in policymaking for triggering resilient low-carbon economic growth and in academia for extending models testing the effectiveness of different climate policy mixes.

Keywords

economic growth; enabling business environment; Environmental Kuznets curve; innovativeness; low-carbon economy; middle-income country; renewable natural capital

Full paper

Budzianowski WM. Enhancing low-carbon economic growth by renewable energy uptake in countries with per capita gross domestic product between 10 and 20 kUSD. International Journal of Energy Technology and Policy 2018

RESRB2016.0031

Africa carbon emissions consequences and constraints to renewable energy deployment

Cleus Bamutura[1,2], Wojciech M. Budzianowski[2,3,*]

[1]Pan African University, Institute of Water and Energy Science (PAUWES), Tlemcen University, B.P. 119, Pole Chetouane, Tlemcen 1300, Algeria; [2]Renewable Energy and Sustainable Development (RESD) Group, Wrocław, Poland; [3]Wojciech Budzianowski Consulting Services, Wrocław, Poland; [*]corresponding author email: wojciech.budzianowski@gmail.com

Abstract

Africa has an opportunity to leap frog from the traditional energy model in modern renewable energy to reduce the carbon foot print. This paper provides an overview of the carbon trends in Africa, major climatic events and consequences of global warming in Africa. A discussion on the hindrances to renewable energy deployment in Africa is given. Key recommendations for Africa to leapfrog into a clean energy future are given. The main objective of this paper is to asses Africa carbon emissions, impacts of carbon emissions, the role of developed nations and their responsibility and to give policy recommendations to tackle the climatic impacts in Africa. We also discuss the hindrances to renewable energy deployment in Africa.

Keywords

carbon emissions; renewable energy deployment

RESRB2016.0032

Two-step anaerobic digestion: state of the art and modeling approaches

Karol Postawa[1,*], Wojciech M. Budzianowski[1,2,*]

[1]Renewable Energy and Sustainable Development (RESD) Group, Wrocław Poland; [2]Wojciech Budzianowski Consulting Services, Wrocław; Poland; [*]corresponding author email: karol@postawa.eu, wojciech.budzianowski@gmail.com

Abstract

The article summarizes the state of the art in Temperature Phased Anaerobic Digestion (TPAD). In this process biogas is produced in two separate steps. In the first step the microbial communities that evolve are different, because of temperature phasing. First step, because of higher temperature is dominated by the process of hydrolysis. In opposite, the second step is mostly methanogenesis based. Because of this differences, usually the first step is achieved in a larger vessel. The researches on TPAD focus on optimizing parameters, especially the difference in temperature between the two process steps, reactor sizes for each step or Hydraulic Retention Time (HRT). The first art of the study provides state of the art analysis of TPAD.

The second part of the study aims at characterizing modeling approaches that might be used in TPAD. Further, it proposes a mathematical engineering level model of TPAD which will provide insights into process characteristics. The model is based on kgCOD/m^3 concentration units and the description of input biomass is done by Van Soest method. The results of trial simulation are then compared with literature experimental data and analyzed.

Keywords

biogas; TPAD; biomethane; temperature difference; engineering process model

Full paper acknowledgment

Full papers submitted for publication to journals or edited books should acknowledge the conference presentation.

Acknowledgments
The work has been presented at the 1st Renewable Energy Sources - Research and Business (RESRB) conference held on 22-24 June 2016 in Wrocław (Poland).

Citation format

This publication may be cited as: Proceedings of the 1st Renewable Energy Sources - Research and Business RESRB 2016 conference, June 22-24, 2016, Wrocław, Poland. ISBN 978-83-948507-0-8.
Citation of abstracts: Author1, Author2. Abstract title. Proceedings of the 1st Renewable Energy Sources - Research and Business RESRB 2016 conference, June 22-24, 2016, Wrocław, Poland, RESRB2016.XXXX. ISBN 978-83-948507-0-8.

Feedback from conference participants

" The virtual presentation is a great opportunity for participants who are lacking economic resources. The proceedings are OK. Full paper is subject to internal review. The organization of the congress has been excellent. The organizers answered all my doubts perfectly. I am really satisfied with the conference and I would like to participate on future editions."

Anas Zyadin, University of Eastern Finland, Joensuu, Finland

"It was a very good idea to create this new conference, which had focus on applied knowledge and technology innovation. This concept of promoting entrepreneurship in academia is definitely essential to develop high impact solutions that generate income and real impact in the society. As a co-founder of a startup company I find important to interact with other new businesses, in order to share and exchange the main challenges and opportunities of how to create business opportunity from an intellectual property. This topic should be extensively discussed in order to promote entrepreneurship initiatives inside universities and the 1st RESRB was a good environment to make it happen. I am happy that I was able to contribute to this useful conference."

Juliana Miranda Mitkiewicz, MIT Portugal Program, FEUP, University of Porto, Porto, Portugal

Author index


ISBN 978-83-948507-0-8
9 788394 850708