Proceedings of the 2nd Renewable Energy Sources - Research and Business conference

BOOK OF ABSTRACTS

June 19 - 21, 2017, Wrocław, Poland
ORGANISER

Wojciech Budzianowski Consulting Services

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Scope

The Renewable Energy Sources - Research and Business (RESRB) 2017 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 2017 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 2017 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 2nd RESRB 2017 conference aims at most important areas of renewable energy research, business and policy. The second edition brings together 190 authors (vs. 84 in 1st RESRB, see Author index), participating either in-person or virtually. The total number of abstracts in the Proceedings is 69 (vs. 32 in 1st RESRB). Virtual participation enables to hear voices on renewable energy topics from developing countries, from where authors rarely have the opportunity to attend international conferences in-person. RESRB 2017 may therefore have a real impact on science, technology, business and policy, both in developed and developing countries and hence contribute to sharing the sustainable development globally.

Renewable energy sources (RESs) are enormous and widely available in the world. Harvesting renewable energy (RE) and providing it to the society has the potential to accelerate sustainable economic growth and reduce poverty. The characteristic feature of RESs that contrasts with fossil fuels is that the RE source cannot be easily economically controlled, because it is in a distributed way available in nature. This fact immensely affects the economics of RE. Renewable energy business is therefore very specific and this conference attempts to explore it from different angles. Renewable energy economics is more inclusive, compared to fossil fuel economics. Given that RESs are evenly distributed across developed and underdeveloped regions, they are essential for achieving sustainable economic development in all regions. Renewables can mitigate atmospheric greenhouse effect and global warming and be a catalyst for economic growth, thereby achieving energy, economic and environmental sustainability.

Since RESs are evenly distributed and thus strongly interact with societies, not only technology is essential for its harvesting, but also social aspects are extremely relevant. Consequently, interdisciplinary character of RESRB helps to explore how to optimally use solar, wind, biomass and hydro energies within technical and social contexts.

The efficient use of RESs primarily requires (1) effective technology, (2) prepared society, (3) inclusive business environment and (4) policy smoothly linking RESs with these three aspects. Technologies need to be capable of achieving significant net energy input, considering life cycle contexts since some technically underperforming systems may have a tendency to be life cycle energy sinks. Prepared society must be able to support harvesting and effective use of RESs. Since RESs have naturally fluctuating character and storage systems add to
the overall costs, prepared people may harvest and use renewable energy more efficiently and obtain more benefits at a smaller cost. Business environment must be inclusive meaning for example more opportunities to profit from RESs by companies, considering its fundamental characteristics such as distributed nature and limited possibility to economically control the source. Development of policies smoothly linking all these aspects is challenging but only within relevant policy framework RESs can be efficiently harvested and used.

Research in academia and in companies can play an important role in order to develop innovative technological solutions, that deepen the reduction of costs observed in recent years. Research is required to improve project technical, economic and environmental performance as well as provide societal skills to maximise benefits and impacts. Business development directed at capturing the value of RESs is also essential. Businesses relying on RESs require dedicated innovative business models catalysing cute-edge technologies created inside academia into the real world. It is therefore a lot of space for scientific progress for RESRB conferences.

Three RESRB 2017 presentations were highlighted as plenary lectures and eight as keynote lectures. The plenary lectures addressed some of the essential research, business and policy aspects of RESs. They related to (1) bioenergy and biofuels - how to apply research into business practice, (2) relevance of research into RESs for society and (3) energy management strategies for hybrid renewable power systems. The keynote lectures were dedicated to (1) predicting site locations for biomass-using facilities in the presence of traffic flow constraints and environmental risk, (2) optimisation of hybrid renewable energy systems under the physical, economic and regulatory constraints, (3) techno-economic assessment of pruned biomass harvesting, (4) business model innovation, (5) liquid phase pyrolysis of wheat straw, (6) assessing the impact of renewables intermittency on the sizing of standalone hybrid energy systems incorporating storage, (7) torrefaction of the sewage sludge using additives: calcium oxide and lignite and (8) implementation of biogas industry into a greenhouse gas intensive energy system. Most interesting oral lectures and short communications were selected by the included (1) (to be added later).

Brainstorming activity moderated by Budzianowski and Coenen focused on perspectives for the commercialization of renewable energy research. Discussions related to truly commercial research activities, markets, business models, institutional capacity and policies, real economic viability of non-subsidised technologies, diversity across countries, etc. Active participants of this brainstorming committed to write an article together to be submitted for
Awards Committee decided to give the following Awards:
(1) Best conference oral lecture - Magdalena Walczak (Electrochemical evaluation of alloy degradation in molten salt for thermal energy storage in CSP: case study of A36, AISI 304 and 316),
(2) Best conference oral lecture by student - Carole Tanios (Syngas production by means of biogas recovery in the presence of mixed Ni-Co-Mg-Al oxides)
(3) Best conference virtual short communication - Javier Rodríguez Martin (4-E (Energy, Exergy, Environment and Economic) assessment of the SOLUGAS, a solar thermal gas turbine power plant in Spain)
(4) Best conference lecture related to an innovative solution with commercial potential - Juan F. González & José M. Encinar (Pretreatment of organic materials by Hydrothermal Carbonisation (HTC) towards sustainable liquid fuels)

W.M. Budzianowski (draft)
J. Popp
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*speaking author at Extremadura University, Badajoz, Spain
RESRB2017.0002 - Making our renewable energy sources research relevant for society
Frans Coenen*
*speaking author at University of Twente, Enschede, The Netherlands
RESRB2017.0003 - Efficient energy management strategies for the hybrid power systems based on fuel cell and the renewable energy sources
Nicu Bizon*
*speaking author at University of Pitesti, Pitesti, Romania

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*speaking author at University College London, London, UK
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*speaking author at Yeungnam University, Gyeongbuk, South Korea
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*speaking author at Wrocław University of Science and Technology, Wrocław, Poland
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Wojciech M. Budzianowski*
*speaking author at Wojciech Budzianowski Consulting Services, Wrocław, Poland

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<td>09.00-09.25</td>
<td>Registration&lt;br&gt;Venue&lt;br&gt;Wrocław Centre for Support of NGOs “SEKTOR 3”&lt;br&gt;Address: Legnicka 65, 54-206 Wrocław, Poland&lt;br&gt;Google Map search - Wrocławskie Centrum Wsparcia Organizacji Pozarządowych SEKTOR 3&lt;br&gt;How-to-find tips:&lt;br&gt;- cross the gate, enter the parking area, take the last door of the yellow building with heading SEKTOR 3, go upstairs to the 1st floor,&lt;br&gt;- by car you need to drive to Wejherowska street (parallel to Legnicka) from where you can drive into the parking area.</td>
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<td>10.30-11.00</td>
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<td>11.00-11.30</td>
<td>Key note lecture 3 - Session Chair R. Barthos (Room A) &lt;br&gt; RESRB2017.0006 - Techno-economic analysis of the pruned biomass harvesting in apple fruit orchard for energetic purposes - a case study Arkadiusz Dyjakon*, Jan den Boer, Girma Gebresenbet, Techane Bosona, Florian Adamczyk&lt;br&gt;*speaking author at Wrocław University of Environmental and Life Sciences, Wrocław, Poland</td>
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<td>11.00-11.30</td>
<td>Key note lecture 4 - Session Chair J. den Boer (Room B) &lt;br&gt; RESRB2017.0007 - Economic study of the cultivation and utilization of Miscanthus Sinensis ‘Tatai’ “Energy Reed” Csaba Pintér, József Popp*, Péter Balogh, Zoltán Gabnai, Béla Marosvölgyi, Gábor Pintér, Attila Bai&lt;br&gt;*speaking author at University of Debrecen, Debrecen, Hungary</td>
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<tr>
<td>11.30-11.45</td>
<td>Coffee break</td>
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<td>11.45-13.45</td>
<td>Oral lecture session 1 - Session Co-Chairs B. Szabó, S. Giorgetti (Room A) &lt;br&gt; Commercialisation, institutional capacity</td>
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<td>11.45-13.45</td>
<td>Oral lecture session 2 - Session Co-Chairs J.M. Encinar, A. Rezaniakolaei (Room B)</td>
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<td>RESRB2017.0015 - Algal biorefinery: an integrated approach for sustainable development</td>
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<td>Bhaskar Singh, Dipesh Kumar</td>
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<td>RESRB2017.0016 - Recent advances in bio-composites and their potential industrial applications: a review and potential future developments</td>
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<td>Samrand Saeidi, Sara Najari, Farhad Fazollahi, Jiří J. Klemaš</td>
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<td>RESRB2017.0017 - Investigation of saline hydrothermal phases in geothermal brines - modelling and experimental approaches</td>
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<td>Ewelina Kaczowka, Gabriele Wiegand, Jörg Sauer</td>
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<td>RESRB2017.0018 - Analysing distributed temperature sensing data from an asphalt field with smoothing and simple derivative</td>
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<td>J. Birgitta Martinkauppi, Anne Mäkiranta, Erkki Hiltunen</td>
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<td>RESRB2017.0019 - Experimental investigation of using phase change materials for thermal management of thermoelectric generator</td>
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<td>Saeed Ahmadi, Alireza Rezaniakolaei, Lasse Aistrup Rosendahl</td>
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<td>RESRB2017.0020 - Hydrodynamic interaction effects and performance of a co-located offshore wind and wave farm</td>
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<td>Konstantinos Pavlidis, Dimitris Cheliotis, Eva Loukogeorgaki</td>
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<td>RESRB2017.0021 - Electrical response of thermoelectric generator module to transient thermal boundary conditions</td>
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<td>Sajjad Mahmoudi Nezhad, Alireza Rezaniakolaei, Lasse Aistrup Rosendahl</td>
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<td>RESRB2017.0022 - Coordinated reactive power compensation strategy for doubly-fed induction generation wind turbines</td>
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<td>Kamila Nieradzinska, David Campos-Gaona, Olimpo Anaya-Lara, Douglas Bertram, William Leithead</td>
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<td>Oral lecture session 4 - Session Co-Chairs E. Kaczowka, A. Andrzejczyk (Room B)</td>
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<td>RESRB2017.0023 - Second life of lithium-ion batteries for supporting renewables: technical opportunities and challenges</td>
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<td>Maciej Świerczynski, Daniel-Ioan Stroe, Søren Knudsen Kær</td>
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### RESRB2017.0024 - Syngas production by means of biogas recovery in the presence of mixed Ni-Co-Mg-Al oxides
Carole Tanios, Moises Romolos Cesario, Cédric Gennequin, Madona Labaki, Fabrice Cazier, Antoine Aboukais, Bilal Nsouli, Edmond Abi-Aad

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<td>17.00-19.00</td>
<td>Dinner (Restaurant) Restaurant - Express Oriental (in Magnolia Park, 1st floor, next to Helios) Legnicka 58 Wroclaw <a href="http://www.magnoliapark.pl/plan">http://www.magnoliapark.pl/plan</a></td>
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**Tuesday 20 June 2017**

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<td>09.30-10.10</td>
<td>Plenary lecture 2 - Session Chair M. Buddeke (Room A) RESRB2017.0002 - Making our renewable energy sources research relevant for society Frans Coenen* ‘speaking author at University of Twente, Enschede, The Netherlands</td>
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<tr>
<td>10.10-10.25</td>
<td>Coffee break</td>
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<tr>
<td>10.25-10.50</td>
<td>Key note lecture 5 - Session Chair Amit Arora, S. Saeidi (Room A) RESRB2017.0008 - Liquid phase pyrolysis of wheat straw Blanka Szabó, Márton Takács, Róbert Barthos*, József Valyon ‘speaking author at Hungarian Academy of Sciences, Budapest, Hungary</td>
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<td>10.25-10.50</td>
<td>Key note lecture 6 - Session Chair M. Walczak (Room B) RESRB2017.0009 - Predicting site locations for biomass-using facilities with Bayesian methods in the presence of traffic flow constraints and environmental risk Timothy M. Young*, James H. Perdue, Xia Huang ‘speaking author at The University of Tennessee, Knoxville, USA</td>
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<td>10.50-11.15</td>
<td>Key note lecture 7 - Session Chair Amit Arora, S. Saeidi (Room A) RESRB2017.0010 - Torrefaction of the sewage sludge using additives: calcium oxide and lignite Halina Pawlak-Kruczek*, Krystian Krochmalny, Krzysztof Moscicki, Lukasz Niedzwiecki ‘speaking author at Wroclaw University of Science and Technology, Wroclaw, Poland</td>
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<td>10.50-11.15</td>
<td>Key note lecture 8 - Session Chair M. Walczak (Room B) RESRB2017.0011 - Implementation of biogas industry into a greenhouse gas intensive energy system: a scenario analysis with life cycle assessment Wojciech M. Budzianowski* ‘speaking author at Wojciech Budzianowski Consulting Services, Wroclaw, Poland</td>
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<td>11.15-11.35</td>
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<td>RESRB2017.0027</td>
<td>Electrochemical evaluation of alloy degradation in molten salt for thermal energy storage in CSP: case study of A36, AISI 304 and 316 Magdalena Walczak, Fabiola Pineda, Franco Vilchez, Ángel G. Fernández Biofuels</td>
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<tr>
<td>RESRB2017.0028</td>
<td>Biodiesel synthesis by transesterification of high acidity fats Magdalena Walczak, Fabiola Pineda, Franco Vilchez, Ángel G. Fernández Waste-to-energy</td>
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<td>RESRB2017.0029</td>
<td>Impact of alternative fuels produced from municipal waste (SRF) on the fire-explosive properties of primary fuels during co-combustion of fuel mixtures Arkadiusz Szydelko</td>
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11.35-13.10 Oral lecture session 6 - Session Co-Chairs R. Barthos, J.B. Martinkauppi (Room B)  
Power system analysis  
RESRB2017.0030 - Comparative analysis of Hybrid Power Systems based on Homer and iHOGA simulators Cristian I. Hoară, Nicu Bizon, Ioan Ştefanescu, Mariana Iliescu, Mihai Culcer Thermo-chemical conversion  
RESRB2017.0033 - Retrospective analysis of bioenergy development in Poland: lessons for the sustainable bioeconomy sector Ewa Krasuska, Magdalena Rogulska Biogas, methane  
RESRB2017.0034 - Influence of acetate as a sole carbon source to enhance biological phosphorus removal Chatlada Piasai, Nittaya Boontian, Usa Yingchon, Htay Aung Pyae Resources - harvesting, processing, modelling  
RESRB2017.0035 - Pruning residues from agriculture - harvesting, potential and practice in Europe A. Dyjakon, D. García-Galindo, W.M. Budzianowski  

13.10-13.50 Short communication session 1 - Session Co-Chairs T.M. Young, B. Singh (Room A)  
RESRB2017.0046 - Introduction of a separate collection scheme of food waste in Wroclaw: a case study Jan den Boer, Przemysław Kobel, Emilia den Boer, Arkadiusz Dyjakon  
RESRB2017.0047 - Biodiesel by means transesterification of sunflower oil with methanol, using lipases immobilized as catalyst Jose M. Encinar, Juan F. González, N. Sánchez  
RESRB2017.0048 - Utilization of solar concentrated collector for preheating drying agent for coal/biomass dryer Halina Pawlak-Kruczek, Jacek Kasperski, Magdalena Nemší, Marcin Baranowski
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<td>RESRB2017.0049 - Harvesting of apple (Malus Mill.) pruning in Germany using a new pruning round baler prototype</td>
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<td>Arkadiusz Dyjakon, Florian Adamczyk, Paweł Frąckowiak, Michał Szaroleta, Luigi Pari, Allesandro Suardi, Sonia Germer</td>
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<td>RESRB2017.0050 - Numerical modelling of anaerobic digestion of different biomasses in a batch reactor</td>
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<td>Juan F. González, Ana I. Parralejo, Jerónimo González, Andrés Álvarez, Eduardo Sabio</td>
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<td>RESRB2017.0051 - Electrical and magnetic properties of carbon fibers coated with Fe-Ni alloy</td>
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<td>Woong Han, Hye-Min Lee, Jin Tae Kim, Yong-Sik Chung, Byung-Joo Kim</td>
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<td>RESRB2017.0036 - Contribution of chemical storage to the future energy networks</td>
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<td>Véronique Dias, Simone Giorgetti, Maxime Pochet, Svend Bram, Laurent Bricteux, Sebastian Verheslt, Julien Blondeau, Hervé Jeanmart,</td>
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<td>Francesco Contino, Alessandro Parente</td>
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<td>RESRB2017.0037 - The role of hydrogen storage as central flexibility option to reach 100% renewable cover rate in 2050</td>
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<td>Mathis Buddeke, Frank Merten</td>
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<td>RESRB2017.0038 - Investigation of treatment and assessment options with determining methane gas potential: application example</td>
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<td>RESRB2017.0039 - Increasing efficiency of biogas Cassava pulp with pretreatment</td>
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<td>Nittaya Boontian, Usa Yingchon</td>
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<td>RESRB2017.0040 - Influence of silica gel and lipopeptide biosurfactant on methane hydrate kinetics</td>
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<td>Amit Arora, Swaranjit Singh Cameotra, Rajnish Kumar, Chandrajit Balomajumder, Anil Kumar Singh, Pushpendra Kumar, Sukumar Laik</td>
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<td>RESRB2017.0041 - Analog model of a flat plate solar collector dynamics for use in control algorithms</td>
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<td>Joanna Aleksiejuk, Andrzej Chochoewski</td>
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<td>15.45-16.40</td>
<td>Brainstorming - Moderators W.M. Budzianowski, F. Coenen (Room A)</td>
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<td>Perspectives for the commercialization of renewable energy research - commercial research activities, market, business models,</td>
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<td>institutional capacity and policies, real economic viability of non-subsidised technologies, diversity across countries, etc.</td>
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<td>17.00-19.00</td>
<td>Dinner (Restaurant)</td>
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<td>Plenary lecture 3 - Session Chair J. Popp (Room A)</td>
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<td>RESRB2017.0003 - Efficient energy management strategies for the hybrid power systems</td>
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<td>based on fuel cell and the renewable energy sources</td>
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<td></td>
<td>Nicu Bizon*</td>
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<td>*speaking author at University of Pitesti, Pitesti, Romania</td>
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<td>12.50-13.00</td>
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<td>Oral lecture session 9 - Session Co-Chairs N. Bizon, K.-Y. Shin (Room A)</td>
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<td>Thermo-chemical conversion</td>
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<td>RESRB2017.0042 - Identification of kinetic parameters for CO₂ hydrogenation to</td>
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<td>hydrocarbons by differential evolution (DE) strategy</td>
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<td>Samrand Saeidi, Sara Najari, Farhad Fazollahi, Jiří J. Klemeš</td>
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<td>System evaluation, control</td>
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<td>RESRB2017.0043 - Enhanced anaerobic digestion by using solid-state and</td>
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<td>Wojciech M. Budzianowski</td>
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<td>14.00-15.30</td>
<td>Short communication session 3 - Session Co-Chairs W.M. Budzianowski, K.</td>
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<td>Pavlidis, J. Oláh, K.-Y. Shin, O.O. Amusat (Room A)</td>
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<td>RESRB2017.0053 - The use of adhesive material to enhance cell aggregation under</td>
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<td>shear stress in high-rate anaerobic reactors</td>
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<td>Maneerat Khemkhao, Somkiet Techkarnjanaruk, Chantaraporn Phalakornkule</td>
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<td>RESRB2017.0054 - Incorporating stakeholders participation and environmental</td>
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<td>impact assessment in site selection of hybrid offshore wind and wave energy</td>
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<td>systems in Greece</td>
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<td>Eva Loukogeorgaki, Dimitra G. Vagiona, Margarita Vasileiou</td>
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<td>RESRB2017.0055 - Energy efficient breweries</td>
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<td>Mariusz K. Nowak, Wojciech M. Budzianowski</td>
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<td>RESRB2017.0056 - 4-E (Energy, Exergy, Environment and Economic) assessment of the</td>
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<td>SOLUGAS, a solar thermal gas turbine power plant in Spain</td>
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<td>Javier Rodríguez Martín, Susana Sánchez-Orgaz, Ángel Jimenez Álvaro, Celina González</td>
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<td>Sustainable ethanol production from waste biomass in semi-arid and tropical regions</td>
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<td>Woody biomass potential and mitigation of territorial disparities in center development region of Romania</td>
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**15.30-15.45**

| Coffee break (Hall) |

15.30-15.45 Award Committee meeting (Room C)

(1) Best conference oral lecture (all oral lectures and short communications, plenary and keynote lectures are excluded)

- Presenting author is entitled to in-person or virtual participation either in 3rd RESR2018 or 1st SSG2018 with fee waived, his/her new high quality lecture might be invited as keynote.

(2) Best conference oral lecture by student (all students - MSc and PhD; all oral lectures and short communications, plenary and keynote lectures are excluded)
- presenting author is entitled to in-person or virtual participation either in 3rd RESRB 2018 or 1st SSG 2018 with fee waived,
(3) Best conference virtual short communication (all virtual short communications)
- first corresponding author is entitled to virtual participation either in 3rd RESRB 2018 or 1st SSG 2018 with fee waived.
(4) Best conference lecture related to an innovative solution with commercial potential (all types of lectures)
- presenting author is entitled to in-person or virtual participation in 1st Sustainable Solutions for Growth 2018 conference with fee waived, his/her new high quality lecture might be invited as keynote
Awardees will be announced at RESRB 2017 and included in Proceedings. Awardees will be considered for inclusion in the ISC/SAB of RESRB 2018, the editorial board of Journal of Renewable Energy Sources - Research, Business and Policy and the IIC/SAB/EAB of SSG 2018.
Award Committee consists of experts invited by the Conference Chair: K.-Y. Shin, M. Walczak, A. Dyjakon, J. Oláh, E. Krasuska, A. Arora; and evaluates candidates for awards (1) - (3) using the following criteria: (i) relevance to RESRB scope (10%), (ii) scientific excellence (30%), (iii) innovativeness and promise for business practice (30%), (iv) quality of oral presentation and/or slides (30%). For award (4) there are three criteria: (i) novelty (30%), (ii) innovativeness and promise for business practice (50%) and quality of oral presentation and/or slides (20%). Award Committee members suggest a maximum of two candidates for each award. The final decision is made during the Award Committee meeting by voting.

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<td>(1) Best conference oral lecture - Magdalena Walczak</td>
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<td>(2) Best conference oral lecture by student - Carole Tanios</td>
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<td>(3) Best conference virtual short communication - Javier Rodríguez Martin</td>
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<td>(4) Best conference lecture related to an innovative solution with commercial potential - Juan F. González &amp; José M. Encinar (Pretreatment of organic materials by Hydrothermal Carbonisation (HTC) towards sustainable liquid fuels)</td>
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BOOK OF ABSTRACTS
Bioenergy and biofuels - applying research for business

Juan F. González1,*, Ana I. Parralejo2, Jerónimo González2, Andrés Álvarez1, Eduardo Sabio1, Silvia Román4, Beatriz Ledesma1, Sergio Nogales3, Nuria Sánchez3, José M. Encinar3

*speaking author at Extremadura University, Badajoz, Spain

1Departament of Applied Physics, Universidad de Extremadura, Badajoz, Spain; 2Department of Extensive Crops, Cicytex, Guadajira, Badajoz, Spain; 3Department of Chemical Engineering and Physics, Universidad de Extremadura, Badajoz, Spain; *corresponding author e-mail: jfelixgg@unex.es

Abstract
Last decades have witnessed an increasing prominence of biofuels in world socioeconomic development. In this context, green energies and biofuels have been presented as realistic alternatives to mitigate the well-known problems like climate change, energy security...

Wide research in this field has been developed from the industrial and productive sectors. This work comprises a study on the exploitation of wastes from different activities such as the forest and food industries, which are presented as a purposeful way to improve energy scenario related issues. The different assessments include solid, liquid and gas phases from organic materials.

The carbonization process, as a path to increase the added value of some materials is one of the mechanisms presented, moreover the hydrothermal carbonization (HTC) could even deal with high humidity content materials, allowing to obtain highly valuable products.

On the other side, in the field of liquid biofuels, biodiesel and bioethanol are natural substitutes to conventional fuels. The last valorisation fraction is the gas approach by two possible mechanisms, methanization and gasification. These processes allow to obtain gas rich in methane, or syn-gas, respectively.

In some cases, the integration between the research scale and the final purpose or industrial use has been demonstrated. For instance, some complex interaction and possibilities can be found in the case of HTC, which can be tuned up towards a desired final output properties, such as a high nitrogen content in the liquid phase, or an enhanced carbon capture in the solid phase. Another highlighted integration example can be the growing of microalgae in photobioreactors and their further use for biodiesel production by transesterification processes. Gasification processes are nowadays enough developed to produce energy in a manageable way; however, there are still knowledge gaps regarding the differences in behaviour associated to dissimilar feedstock. In this sense, pilot plants are quite useful to determine the quality of the gas produced and open a wide range of opportunities in order to demonstrate, develop and optimize new process conditions.

Keywords
bioenergy; biofuels; hydrothermal carbonization

Acknowledgments
The authors are grateful to financial support by “Ministerio de Economía y Competitividad”, Spanish Government for financial help through project CTM2014-55998-R and CTM2016-75937-R & FEDER; the funding support by “Junta de Extremadura” for financial help through project GR15034, and IB16108
& FEDER.
Making our renewable energy sources research relevant for society

Frans Coenen1,*

*speaking author at University of Twente, Enschede, The Netherlands

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Abstract

Researchers, particular in the field of energy and climate, do not only want to follow their own research interest but also want to take a responsibility for climate change as one of the greatest societal challenges. Although everybody agrees how important technological innovations are for a transition towards a sustainable energy society, innovations only diffuse very slowly. While researchers in various settings came with numerous, promising innovations with a great potential to address climate change, it took for instance the OECD countries more than 40 years of developing sustainable energy technologies to reach a 10 % share of modern renewables. Literature provides us with many explanations why promising innovations are not used, like the mechanism of carbon-lock in. How could society, business and governments better benefit from renewable energy research? We will address this question from the perspective of the research community. We recognize that many problems and market barriers have to be solved by business and government actors on the market. But how can researchers that want their innovation to be used, better anticipate on these problems and barriers. A first aspect is to find out early what is needed in the market and what is prioritised by governments and what role research and innovations can play. A second aspect is how researcher can better show what they have to offer with their research given these needs. And a third aspects is the understanding of how innovations get to be used. These three aspects cannot easily be separated from each other. We will discuss how to find out what technologies might be needed and probable will be prioritised, by looking at examples of climate scenarios like the French Négawatt scenario. And what we can learn from the implementation of the Paris Agreement and EU Climate goals into national and regional agreements between a broad coalition of stakeholders in the Netherlands. And how this relates to the Dutch with national research programmes. Than we will illustrate how the potential of innovations can be showcased in real life experiments that form either protected market niches in the energy market or hybridisations with existing technologies. Particular we will address the importance of shared visions between researchers, government, business and other stakeholders in creating these niches, how researchers can contribute to the accumulation of niches in sustainable energy technologies and to the difference between linear innovation processes and niche accumulation.

Keywords
renewable energy; policy; business
Efficient energy management strategies for the hybrid power systems based on fuel cell and the renewable energy sources

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Abstract
This paper deals with efficient Energy Management Strategies (EMS) proposed for the Hybrid Power Systems (HPS) based on Fuel Cell (FC), Renewable Energy Sources (RESs), and Energy Storage System (ESS).

First, the main FC/RES/ESS HPS topologies are shown and discussed as efficiency for a passive and regenerative load. The case study will be a FC/ESSs HPS used in FC vehicle (FCV) operating the ESS in three modes: Charge Sustaining (CS), Charge Discharging (CD), and Charge Increasing (CI). The EMS unit commands the power interfaces used to charge the ESS from the FC system and regenerative load based on state variable of the FCV such as the ESS State-Of-Charge (SOC), profile of the drive load, the route to be followed, and the plug-in features on the route.

Second, the efficiency of the FC system and different RESs such as the Photovoltaic (PV) panels and Wind Turbines (WT) is investigated using the Maximum Efficiency Point Tracking (MEPT) algorithms, and Global Maximum Power Point Tracking (GMPPT) and MPPT algorithms, respectively. The hydrogen flow or the both hydrogen and oxygen flows of the FC system will be controlled to track the MEP or MPP under a dynamic load profile. The efficiency of large PV array under Partially Shaded Conditions (PSCs) is analyzed considering GMPPT and MPPT algorithms.

Third, the Renewable Energy Sources (RESSs) are added on DC bus or AC bus of the FC/ESS HPS. The variability of RESSs is mitigated using the load following control to sustain the load demand in an efficient way. The efficiency is maximized for the whole FC/RES/ESS HPS by using the Extremum Seeking Control (ESC) for the both fuel flows of the FC system. Different ESC algorithms are reviewed and compared with other optimization algorithms proposed.

Keywords
Fuel Cell (FC); Renewable Energy Sources (RES); Photovoltaic (PV) panels; Wind Turbines (WT); Energy Storage System (ESS); State-Of-Charge (SOC); Hybrid Power Sources (HPS); FC vehicle (FCV); Energy Management Strategy (EMS); Maximum Efficiency Point Tracking (MEPT) algorithms; Global Maximum Power Point Tracking (GMPPT) algorithms, Extremum Seeking Control (ESC)

Acknowledgments
Assessing the impact of renewables intermittency on the sizing of standalone hybrid energy systems incorporating storage

Oluwamayowa O. Amusat, Paul R. Shearing, Eric S. Fraga

Abstract

Renewable energy sources such as wind are variable and intermittent by nature and require integration with suitable storage technologies in order to attain higher levels of penetration into the energy grid. In previous works [1, 2], we showed that variability can have a significant impact on design performance and developed a methodology for accounting for it at the design stage. In this work, we focus on assessing the impact of intermittency on the design of standalone hybrid renewable energy systems for continuous operations.

The challenge of the sizing of a hybrid system consisting of three potential generation technologies (solar thermal, photovoltaics, wind) and four storage options to meet the thermal and electrical load demands of a typical mine located in Canada is considered. The energy system is modelled as a nonlinear system of differential algebraic equations (DAE). Variability is accounted for by providing multiple renewable input scenarios generated stochastically from probability distribution functions as inputs into the system model. The modified loss of power supply probability [1] is used to assess design reliability over all the input scenarios. The impact of intermittency on system sizing is investigated by studying how the introduction of constraints which control the dispatch and operation of the storage systems during power generation fluctuations affect the configuration and cost of the optimal energy system. The operating characteristics of the configurations are also explored.

The methodology presented ensures that both sudden fluctuations and temporal variations are accounted for in the design of renewables-based energy systems, thereby providing the decision-maker with an understanding of the performance risks associated with the selection of any given design.


Keywords
hybrid energy systems design; intermittency; optimization; reliability; renewables variability
Optimization of hybrid renewable energy systems under the physical, economic and regulatory constraints

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Abstract
As micro energy grids are built up, a grid-level analysis of combined energy performance of buildings is required include renewable energy resources. This paper presents a novel building energy simulation program for micro-energy grid design. The objective of this program is to optimally design a micro energy grid including various types of buildings and combined energy loads, such as electricity, heating, and cooling sources. The optimal design conditions can reduce operating costs. The program predicts the initial cost for systems installation, the operation efficiency of the energy grid systems, and their performance, and it optimizes them by simulation. The program is set up in three steps of the computing module: building and energy grid design, operation simulation, and sensitivity analysis with economic factors. A drag-and-drop concept was implemented to design each building and device in the grid model. In the simulation and cost analysis, the program calculates the time series based on the demands for electricity, heating, cooling, and hot water loads for 8,760 hours of a year. The structure of the simulation program and a project implementation are presented in detail.

Keywords
renewable energy resources; micro energy grid; combined energy simulation; economics; sensitivity analysis; drag and drop design
Techno-economic analysis of the pruned biomass harvesting in apple fruit orchard for energetic purposes - a case study

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Abstract
The limitation of fossil fuels combustion for heat and electricity production together with the assurance of sustainable development strategy able to cover all energy demands are one of the main concerns for many countries in Europe. Therefore, more and more attention is paid to new directions of renewable energy acquisition, especially those, which are available locally and have potential to be used in the region. In Poland, there are ca. 350 000 hectares of orchards, in which more than 50% are apple trees orchards. This crop require annual pruning to maintain good fruit productivity and thus generate a substantial amount of wooden residues which must be removed from orchard or mulched in situ. Finding the use of this problematic residue would allow converting the undesirable waste into valuable product and potential to additional financial profits or reduction of management costs.

In the paper a case study for the 100 ha apple orchard is presented, where the farmer follows the pruning to energy (PtE) strategy. This strategy is realized through out the harvesting of the pruning residues by their baling using the baler machinery, temporary storage on-side and delivery of the bales to the local boiler house for heating. The economic analysis based on the NPV and IRR indices indicated that after 10 years the NPV=6150 EUR, and the IRR=13,69%. The calculated payback time for the farmer (NPV=0) is 7-8 years. The performed sensitivity analysis revealed that the most influencing parameters on the economic analysis are pruning potential, orchard area and pruning residues price at the final user gate. The distance to the final user (6 km in this case) and the labor costs in the orchard have lower impact on the final economic result.

Keywords
biomass harvesting; energy; apple orchard; techno-economic analysis

Acknowledgments
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Economic study of the cultivation and utilization of Miscanthus Sinensis ‘Tatai’ “Energy Reed”

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Abstract

The most perspective source of renewable energy is the biomass both in the EU and in Hungary. To widen the range and to reduce the cost of biomass production, Miscanthus sinensis ‘Tatai’ (MsT) “energy reed” variety offers a cost-benefit analysis. This study is based on MsT production on 50 hectares between 2009-2014 in Tata, Ács and Nagyszentjános (Hungary). Relatively little attention has been paid to the economic potentials and limitations of Ms production. Our main objective is to evaluate the economic viability of the MsT including the cheap production of propagating material, plant density, harvesting technology and transportation costs. In a laboratory we tested the micro-breeding process with a new propagating method by cutting MsT stalks into 10-15 cm long sections. For determining the optimum distance between rows and plants, plantations of a test area of 1, 2, 5 and 7 ha were executed under same weather conditions and with different values for the distance between rows and plants (2.500, 6.600, 10.000, 12.500 plants/ha). Larger than 1 ha sized, at least 2 years old MsT plantations in different growth period were tested one month before harvesting (5 different plantations, in size of 3×10 m2, random settled, average growth MsT plantation). The basic criteria for the MsT harvesting technology was that the “energy reed” harvested should be ready-made for burning by biomass power plants, i.e. to meet the requirements of end-users. The economic calculations were done with the use of net present value (NPV) calculations and sensibility analyses. The actual prices, costs and yield results were taken into account. We found that cheap and vital propagating material can be produced with the help of the cutting of rhizomes, while the method of cutting second year old, strong MsT roots in two pieces (including numerous rhizomes) is very slow, but effective and should be used especially for replacing died plants. In case of split of rhizomes the propagating material was suitable for immediate planting, using a method based on the removal and cutting up of MsT rootstock in their 3rd year. Inexpensive propagating material can be created with the large-scale industrial roll-out of this solution, and this can be a real benefit as compared to more expensive micro-breeding technology. Based on the tests we found that 10.000 plants or 12.000 rhizomes per hectare can be regarded as optimal. Smaller number of plants would result in more intensive weed activity and underused potential, while higher plant density can result in malnutrition and stunted growth. This is why the spacing between plants and plant density has to be always controlled to produce better yields. The estimations of yields were very differential from the actually harvested results. The reason for this was the lack of homogeneity of the test areas since cutting and measuring 30 plants per hectare is not a representative sample quantity. For a reliable yield estimation at least 1.000 plants per hectare are needed. Based on experiments of harvesting technologies a method was established consisting comprising stalk crushing, windrowing, baling, repositioning bales and transporting the bales to the end-users. We also made economic calculations with the conclusion that the profit generated by the sale of the plants is highly sensitive to the yield, producer price, weight of the bales and the transport distance. The results of the NPV calculation support the conclusion that
the cultivation and use of MsT “energy reed” can be profitable. The net present value of the investment (planting of MsT) can reach 5,280 EUR/ha during a 20-year-long production period. The transport margin distance of 250 km is highly sensitive to the variation of the transport cost/km, the weight of the bales and the producer price of the biomass including transport. MsT deserves more attention because it should become a reliable and relatively cheap local biomass plant in the future.

**Keywords**

energy crops; economics; biomass
RESRB2017.0008

Liquid phase pyrolysis of wheat straw

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Abstract

There is a need for replacement of fuel, especially transportation fuel, obtained from fossil resources by bio-based alternative. The thermochemical conversion of lignocellulosic material is a feasible method to degrade and partially deoxygenate natural polymeric materials to get bio-oils as fuel precursors. Thermal degradation of lignocellulose under water is usually referred as high-temperature liquefaction (HTL) or high-temperature carbonization (HTC). This method requires severe conditions, such as, 50-200 bar pressure and 250-350 °C temperature. An alternative route to process lignocellulosic materials is degradation in none-hydrogen donor organic solvent referred to as degradative extraction (DE) or liquid phase pyrolysis (LPP). According to LPP method lignocellulosic material is treated at ~350°C under liquid phase organic solvent and inert atmosphere at relatively low pressure (max. 20 bar). The solvent acts as a heat carrier, having high heat transfer rate, and as media for extracting and dissolving degradation products. The method gives three types of solid materials: (i) solvent-insoluble residue (ii) extract insoluble at room temperature (iii) extract soluble at room temperature. Gases, mainly CO2, and liquid, non-miscible with the applied solvent, mainly H2O, also form. The degradation process in LPP can be directed by the selection of solvent, catalyst and the applied treatment conditions. The relationships of the properties of raw material, the treatment conditions and the product yields are poorly understood.

Our research is focused on the better understanding of the mechanism of lignocellulose degradation in the LPP process. Reactions were executed in Parr-type autoclave. The influence of reaction temperature, residence time and the kind of organic solvent (hexadecane, 1-methyl-naphtalene) on the product yields was investigated. Effect of solid acid and base catalysts, such as zeolite, Nafion®, Amberlyst 15, sulfated zirconia, Mg,Al-Layered Double Hydroxide and MgO, on the product yields was examined. The reaction products were analyzed by means of CHNO elemental analysis, GC-MS, 1H and 13C NMR spectroscopy. The carbon and oxygen mass balances were determined in order to optimize the conditions of carbon transfer from lignocellulose to bio-oil.

Keywords
biomass deoxygenation; biomass to liquid; wheat straw; product analysis; solid acid and base catalysts

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Predicting site locations for biomass-using facilities with Bayesian methods in the presence of traffic flow constraints and environmental risk

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Abstract
This objective of the study was to estimate the impact of transportation infrastructure and related risks for the emerging bioeconomy. Bayesian inference was applied in the context of logistic regression models to estimate probabilities for site locations for biorefineries for the southern United States. Large volumes of data were organized into a relational database from the U.S. Census Bureau, U.S. Forest Service, U.S. National Land Cover Database, U.S. National Elevation Dataset, U.S. Department of Agriculture National Agricultural Statistic Service, U.S. Environmental Protection Agency, and from BioSAT (Perdue et al. 2011). BioSAT provides geo-spatially explicit information on economic biomass supply. BioSAT (www.biosat.net) was used to estimate woody biomass supply for procurement zones assuming a 128.8-km one-way travel distance given the existing road network. Data were organized using the U.S. Census Bureau 5-digit ZIP Code Tabulation Area (ZCTA) level. There were 10,016 ZCTAs (average area of 209.84 km) in the study region which represented the potential sites for woody biomass plants. Prior research in this field, organized data at a larger area and lower resolution using the county boundary and did not include Bayesian inference.

Five out of the possible 14 predictor variables were statistically significant (p-value < 0.05). Median Family Income, Timberland Annual Growth-to-Removal Ratio, and Transportation Delays were highly significant in influencing mill location (p-values <0.0001) for smaller-sized mills similar to the capacity of sawmills or wood pellet mills. The sensitivity of this model assuming a uniform prior in validation was 89% (e.g., predicts a mill location correctly 89% of the time), and specificity was 92.3% (e.g., predicting no mill location correctly). The higher probability locations for smaller-sized mills were clustered in the southern Alabama, southern Georgia, southeast Mississippi, southern Virginia, western Louisiana, and eastern Texas regions. Median Family Income, Urban Land Area Ratio, Number of Primary Wood Processing Mills in Each ZCTA, and Transportation Delays were highly significant influencing mill location (p-values < 0.0001) for larger, paper-mill sized biorefineries. The sensitivity of this model was 90.5% and specificity was 87.7%. The higher probability locations for larger mills are clustered in the southeast Alabama, southern Georgia, central North Carolina, and Mississippi-Delta regions.

Keywords
biorefinery; Bayesian; biomass; transportation; models; site locations

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Torrefaction of the sewage sludge using additives: calcium oxide and lignite

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Abstract

The research subject was to find a safe way to stabilize sewage sludge by means of torrefaction process using different additives to improve fuel parameters. The aim of pretreatment was to obtain solid fuel with more uniform properties, relevant for its later utilization. Torrefaction is a promising pretreatment that has a potential of modifying parameters of the solid fuel. Assessment of benefits of the sewage sludge pretreatment via torrefaction was done by performing a suite of laboratory scale experiments. A limited amount of literature on torrefaction of sewage sludge has been performed so far. Some researchers performed co-torrefaction of different feedstocks with sewage sludge. However, use of lignite as co-feedstock is a novelty. Use of additives, such as CaO has never been a subject of extensive research.

Samples of feedstock were obtained at sewage treatment plant. Samples of sewage sludge were taken after fermentation and mechanical drying stages of the sewage treatment.

Tests were carried out at a laboratory scale using isothermal rotary reactor. Feedstock was torrefied at three temperatures: 250, 275 and 300 °C with residence time of 40 minutes in inert atmosphere. Nitrogen was used as an inert gas. Mass yield and energy yield were assessed as two fundamental quantities describing the process.

The additives used for the torrefaction tests were respectively: lignite and calcium oxide. In both of the cases 10% of an additive by mass was added. Lignite was examined because of possibility of torgas improvement. It was expected that addition of lignite will increase the heating value of the torgas in order to maintain a suitable torrefaction temperature. Calcium oxide, on the other hand, CaO is typically added in sewage treatment plant for the purpose of the removal of pathogens. It was expected to act during torrefaction as a catalyst that would enhance thermal decomposition of condensable compounds in torgas. Feedstock had been pre-dried to approximately 8% of moisture content, before co-torrefaction tests, performed with addition of lignite. Raw feedstock, with moisture content of approx. 80%, was used for tests with CaO as an additive.

Gaseous products of torrefaction were measured using FTIR analyser. Condensable compounds were captured by washing gas with impinger bottles, filled with water and cooled with ice-bath. Proximate analysis of feedstocks and products was performed using TGA. Ultimate analysis was performed using Perkin Elmer 2400 analyser, according to polish standard PKN-ISO/TS 12902:2007 (standard is compatible with ISO). Higher heating value was determined using IKA C2000 basic bomb calorimeter, in compliance with ISO 1928. Isoperibolic method was used. Lower Heating Value was calculated using moisture content. Equilibrium moisture content was assessed by measuring moisture content increase during storage in a room with constant relative humidity.

Out of non-condensable gaseous compounds, obtained during torrefaction, carbon monoxide was by far the most abundant. As a result of mixing calcium oxide with wet sludge, a significant increase in fuel temperature was observed, intensifying the torrefaction process (drying) together with the release of significant amounts of ammonia.
It was observed that Equilibrium Moisture Content (EMC) decreased with increasing temperature of the process, which indicates improvement in storage properties of torrefied sewage sludge in comparison with the raw feedstock. Also rates of the moisture uptake was the highest for the raw, dried sewage sludge and decreased with increasing temperature of torrefaction.

**Keywords**
biomass; sewage sludge; torrefaction; catalytic slow pyrolysis; stabilization of sewage sludge
Implementation of biogas industry into a greenhouse gas intensive energy system: a scenario analysis with life cycle assessment

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Abstract
The integration of biogas industry (BI) with a fossil fuel intensive energy system may reduce GHG emissions and accelerate sustainable economic growth. This study performs a scenario analysis coupled to life cycle assessment in order to estimate GHG emissions from the energy system with BI. Two life cycle indicators are employed in the research: (1) GHG footprint and (2) Energy Return on Energy Invested (ERoEI). The analysis is made for the energy system of Poland from 2000 to 2100. Revealed policy implications suggest that energy policies associated with implementing BI into energy systems need to be varied in the future. In the short term, policies encouraging investments increasing the adoption rate of BI are required. The reason is that life cycle GHG footprint of BI is currently much lower than that of fossil fuel intensive energy systems and the ERoEI of BI is usually above 2. In the long term, policies encouraging technological innovation within BI by R&D will be necessary. Only most effective biogas projects should be implemented, i.e. these able to meet sustainability criteria such as life cycle GHG footprint and ERoEI. The reason is that renewable energy deployment may reduce GHG intensity of energy systems and only truly sustainable solutions will make a difference. It is suggested that current LCA methods for BI require refinement, especially regarding the assessment of life cycle ERoEI.

Keywords
biogas; energy system; GHG footprint; ERoEI; life cycle assessment

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The support obtained from Wojciech Budzianowski Consulting Services under the project no. WBCS-RDG01/2017 is greatly acknowledged.
Bridging the gap between renewable energy technology research and market introduction. The role of research institutes and user-centred cooperation and partnership

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Abstract

Polish research has made great advances in building technological expertise in many of the renewable energy technologies needed for an green energy transition. However the roll-out of these renewable energy technologies in society and in the energy market in Poland is, likewise several Central European countries though a few are in the forefront of the EU-countries. Typically in this phase of the energy transition in the lower-performing EU-countries in the energy transition, technology actors usually focus on developing, testing and optimising technology and leave the societal implementation of these technologies to a later stage. Setting up special research programmes in R&D settings or demonstration projects in itself might not be enough to directly bridge the gap between R&D and market introduction. As intermediate step the living lab as a research concept, real-world experimental projects, and other similar technology user-centred cooperation and partnership models are needed. Experiences suggest that such living labs entail large scale implementation on local and regional levels. In the context of the Horizon 2020 project SUPREME the paper explores the first experiences and difficulties with real-world experimental projects as important initiatives that precede further market niche development. These experimental projects potential align technology, user demands and sustainability issues. Models for user-centred cooperation and partnership are discussed in the paper.

Progress will to be assessed against the Polish landscape of a historical legacy of coal dependency, a slow-developing economy and a changed political climate. Lessons on technological, economic, social, political, and practical factors that might form barriers in the energy transition are drawn. The explored factors are based on implementation literature and system innovation literature, particular internal and external project process factors from the strategic niche management (SNM) literature.

The specific role of sustainable energy research institutes will be discussed on the bases of the Jablonna Energy Conversion and Renewable Sources (KEZO) example. The choice for minor variations of prevailing technologies in real world experiments will be compared with more radical innovations that ask according to SSM scholars for protected market niches.

Keywords

energy transition; RES real-world experiments; strategic niches; RES research institutes; research cooperation and partnership
Impact of biofuel output on oil and food commodity prices

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Abstract
The food versus fuel debate has been discussed very intensively in the last decade, and the correlation between crude oil prices and food prices attracted significant attention. Meanwhile, fuel-dependency of food production has become stronger as well. It is clear, that oil prices have influenced the development of the biofuel industry due to a clear connection of the two products in the energy market. The objective of this paper is to get an answer to the cause of increased food commodity volatility. The analysis focuses on whether the volatility in food commodities is driven just by the oil market or is the result of increasing biofuel production. We present evidence on the link between food and oil prices, especially for those crops used for biofuels production.

We investigate the role of biofuels in order to explain increasing price volatility in food products and crude oil by analysis of the correlations and co-movements between the price index of food products used in the production of biofuels (cereals, sugar and vegetable oils), and oil prices over the years 2000 to 2016. The relationships between times series of these prices are investigated using a Vector Error Corrections Model (VECM), supported by Granger Causality tests. In addition, Impulse Response Functions and Forecast Error Variance Decompositions are computed, in order to investigate the dynamic interrelationships within these series. Data are statistically analysed using the different packages of the R program. Main sources of data are the FAO (food, cereals, sugar and vegetable oil prices represented by an index), World Bank (crude oil price) and OECD Agriculture statistics (global biofuel production and consumption). We use yearly and monthly data (2000 to 2016) for crude oil price, cereals, sugar and vegetable oil price index. Two groups of food and agricultural commodities are considered: biofuel foods (maize, sugar, rape, soybean, palm oil) and non-biofuel food products (wheat, rice). This research provides some evidence that biofuel production has strengthened the link between food prices and oil prices, especially for those food products that are used for biofuel production. The variances in food commodity prices can be justified mostly by the contribution of oil price shocks. Our analysis provides some indications of biofuel production emphasizing the existence of an additional link between food and oil prices.

Keywords
biofuels; food; crude oil; cointegration; correlation
Environmental effects of a local Pruning-to-Energy scheme

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Abstract
Poland is the largest apple producer in Europe and the third largest producer of the world after China and the United States, with an area of over 200,000 hectares. On a yearly basis, apple orchards are pruned, producing in average 3.5 Mg of pruning residues per hectare. Currently, the pruning residues are left on the field and consequently either mulched, leaving the mulched material in the orchard or burned on site or outside of the orchards. In either way, the energetic potential of the pruned material is lost for further use.

In Poland the main source for electricity as well as heat production is coal. Apart from a high amount of CO₂ generated per unit of energy, it also leads to significant amounts of other emissions, causing local air pollution, which results amongst other things in smog. The use of pruning residues for energy production purposes potentially offers a viable alternative for coal combustion. An additional asset of pruning residues as an energy source is the local character of its production: it does not cause a dependence on foreign energy imports.

In the paper a case study for a 100 ha apple orchard is presented. The pruning residues generated in the orchard are harvested by a baling machine. The thus produced bales are dried for six months and consequently combusted as a whole in a nearby boiler house for heat production. The environmental effects of this Pruning-to-Energy (PtE) scheme are assessed and compared to an alternative scenario (which is common in Poland) of mulching and leaving the pruning residues in the orchard, the Pruning-to-Soil (Pts) scheme. For this comparison a Life Cycle Assessment (LCA) is performed, using GaBi software.

The performed LCA study showed that the environmental gain by substitution of the use of bituminous coal by pruning residues outweighs the additional environmental burdens for the collection, storage and transport of the pruning residues. A sensitivity analysis of the obtained results showed, that increasing the transport distance from the actual 6 km by a factor 5 does not lead to significant differences in the outcomes.

Keywords
biomass harvesting; energy; apple orchard; life cycle analysis; pruning residues

Acknowledgments
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Algal biorefinery: an integrated approach for sustainable development

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Abstract
It has been realized that production of a single product (e.g. biodiesel) from microalgae has techno-economic as well as environmental challenges. These issues can be suitably addressed by employing an integrated biorefinery approach in which different biomass fractions are appropriately processed by a range of techniques to produce multiple products. These include biofuels (biodiesel, bioethanol, biobutanol, biohydrogen, biogas, syngas, etc.), bioelectricity, heat and a range of other value added products such as polyunsaturated fatty acids, vitamins, antioxidants, pigments, and protein. Valorisation of these co-products by suitable means can help improve the overall environmental performance of the system and makes algal biofuel production cost competitive with fossil fuels. Legislative mandates for biofuels in primary energy mix have been introduced by several countries and considering the growing public interest in environmentally benign products, algal biofuels and other value added products are likely to be readily absorbed in the market. In this study, we have critically analyzed some of the recent studies on algal biodiesel production using a biorefinery approach for techno-economic feasibility, energetic balance and environmental performance.

Keywords
biorefinery; sustainable development; renewable energy; industrial metabolism
Recent advances in bio-composites and their potential industrial applications: a review and potential future developments

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Abstract

High rate of consuming petroleum resources with awareness of problems regarding global environment of using plastics are the primary compelling forces for the comprehensive acceptance of natural fibers and biopolymers as green materials. Nowadays, Scientists and industries pay high attention to natural fibers and biopolymers owing to their properties of environmentally friendly and sustainable nature such as sugar palm that is grown in tropical climate. Sugar palm fiber (SPF) is composed of cellulose (~66.49%) which leads to its distinguished mechanical property. The extracted starch from SPF can be plasticized, blend with other polymers, and reinforced with fibers to enhance its properties. This review presents the properties of SPF and starch, and their fabrication as green composites, the potential of SPF and biopolymers for industrial applications such as automotive, packaging, bioenergy and others. Finally, by taking the available information into account the novel adsorbent in order to adsorb Urea-formaldehyde is proposed.

Keywords

bio-composites; biomaterials; biochemicals
Investigation of saline hydrothermal phases in geothermal brines - modelling and experimental approaches

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Abstract
The presented research concentrates on investigation of the solubility behaviour of hydrothermal solutions characterised by high salinity at elevated pressures and temperatures, namely geothermal fluids. They are applied in industrial technologies in the area of geothermal energy utility, where energy is recovered from a local geothermal reservoir. In such industrial processes the aqueous fluids are playing a main role as significant and essential mass and energy transfer renewable agents as base load power.

Low-enthalpy geothermal reservoirs, like the one utilised by the geothermal power plant located in Bruchsal, Germany, use binary cycle technologies for electricity production [1]. Those technologies are based on a principle that the energy of the hot water is transferred through a heat exchanger to a separate secondary cycle, where the turbines are driven by a chosen working fluid. While restoring the heat in the heat exchanger, the temperature drop influences the thermodynamic properties of the flowing-through brine system and a precipitation of some dissolved components occurs inside the installation. It leads to the interruptions in the work flow of the power plant or even to its total failure. In order to describe the problematic physical-chemical background of this phenomenon, and therefore to support the optimization of this industrial technology, a cost and time saving combination of modelling and experiments is applied.

A proper and accurate description of mechanisms of thermodynamic processes has to be followed by analyses of the chemical interactions between fluids and surrounding medium. An approach to a reliable quantitative analysis of such systems is often given by numerical modelling of the physical and chemical effects of the investigated processes, as well as their variation in the system respectively to time and space.

One topic is to develop a robust analytical system to enable the investigation of the solubility behaviour of hydrothermal solutions with high salinity at elevated pressures and temperatures by online analyses in a laboratory scale. In a further step, the experimental data are gathered in a form of composition changes of the liquid phase as a function of temperature, in order to visualise the possible process flow and give the information in terms of accuracy of the chosen modelling paths. The existing thermodynamic models suitable for this application are applied and further compared with the gathered experimental data set.


Keyword
hydrothermal phase; geothermal brine; online solubility analyses; modelling
Analysing distributed temperature sensing data from an asphalt field with smoothing and simple derivative

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Abstract
Asphalt covers typically large areas in urban environments. Many papers study the temperature of an asphalt field or road and many models have been developed for temperature prediction. The layers under the asphalt are obviously good heat sources. The temperature of asphalt is important factor because it effects on many things like the heat island phenomenon, quality of air, and need for cooling. Many models are developed using data collected at surface or near surface (e.g. the USA Federal Highway Administration or Swedish National Road Administration). Some papers utilize data fixed point-measurement sensor installation at different depths under the pavement layers.
We employ distributed temperature sensing DTS method to get the thermal profile of asphalt pavement and the underground layers. In this paper, we use thermal profiles with 120 measurement points, from surface of asphalt field to the depth of 3 m during one year period. The objective and novel contribution of this paper is to study the use of smoothing derivatives to this data. We believe that this helps to understand the behaviour of heat transfer as well as developing seasonal heat storages.

An example of original data is shown in the left side image in Fig. 1. The analysis method utilized first apply smoothing in this data (image in the middle in Fig. 1) and then derivative (the right side image in Fig. 1). Although the original data at different depths already is quite smooth, the processed data shows many features. It can be concluded that the applied method produces features which explain heat transferring between layers.

Fig. 1. Left side image - original measurement data, image in the middle - data with smoothing, and right side image - processed with a simple derivate. There are 120 measurement points between surface (measurement point 0) and depth of 3 m (measurement point 120).

Keywords
asphalt energy; heat storage; distributed temperature sensing; machine learning; smoothing derivatives
Experimental investigation of using phase change materials for thermal management of thermoelectric generator

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Abstract
Until now most studies about thermoelectric module (TEM) was in the field of material properties to improve the performance. Power generation by these modules is interesting due to their several advantages which mentioned in the literature. In order to improve the efficiency of a module, various methods can be applied for cooling the cold side of the module. Some of these methods consume some electrical power, whereas they reduce the net power generation and are not reasonable to be used. In this study, phase change materials (PCM) as a kind of passive heat sink, without using any power consumption for cooling system, has been investigated. Phase change materials could save a lot of thermal energy by reaching their melting temperatures and keep constant temperature for a longer time. On the other hand, as the capacity of these materials is limited, so in transient condition with high temperature they cannot be very practical. In this study, using phase change materials for manage the heat input and output of a thermoelectric generator module, different types of geometry and phase change materials have been investigated. The results show that by having a good design for a system like abovementioned, we could have a higher electric power by thermoelectric generator system without using any active procedure as cooling system. Therefore, the result exhibits that higher amount of net power for system is obtainable.

Keywords
thermoelectric generator; phase change materials; transient boundary conditions

Acknowledgments
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Hydrodynamic interaction effects and performance of a co-located offshore wind and wave farm

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Abstract

Offshore wind and wave energy present two abundant marine renewable energy sources. Contrary to the offshore wind energy sector, characterized nowadays by proven technological maturity, the wave energy sector has to overcome many barriers for achieving technological readiness and, thus, ensuring commercialization. The combined deployment of Wave Energy Converters (WECs) with Offshore Wind Turbines (OWTs) through the formation of co-located offshore wind and wave farms, may contribute to the efficient handling of these barriers, offering at the same time multiple benefits (e.g. reduction of costs, increased energy yield, etc). Within such a farm, hydrodynamic interactions between the WECs and the OWTs’ support structures occur, affecting both the WECs’ performance as well as the OWTs’ hydrodynamic loadings. Therefore, these interactions should be adequately considered and examined towards an efficient assessment of the wind-wave farm’s performance.

Motivated by this, in the present paper, the hydrodynamic interaction effects and the performance (hydrodynamic behavior and absorbed power) of a co-located wind-wave farm are numerically investigated. The farm consists of 4 bottom-mounted OWTs with monopile support structure of large diameter and 13 free floating cylindrical WECs. Each WEC is assumed to absorb power through a linear power taking off mechanism, actuated from each WEC’s heave motion. The analysis is implemented in the frequency domain (boundary integral equation method) under the action of head and oblique, regular and irregular (including shoaling phenomena) waves. Focus is given on the effect of the WECs’ configuration and of the wave direction on the hydrodynamic interactions and the farm’s performance. Constructive/destructive interactions in terms of the WECs’ absorbed power are quantified using an appropriate interaction factor. Furthermore, the hydrodynamic interactions’ effect on the OWTs’ hydrodynamic forces is examined by introducing a relevant coefficient (force on an OWT within the farm divided by the force applied on an isolated OWT). Finally, the OWTs’ hydrodynamic loadings and the WECs’ absorbed power are compared with results obtained considering the absence of WECs and OWTs respectively.

The results illustrate that the WECs’ configuration, contrary to the wave direction, affects significantly the farm’s performance, the existence of constructive/destructive interactions, in terms of the WECs’ absorbed power, as well as the OWTs’ hydrodynamic forces. Moreover, the WECs’ existence may lead to smaller forces on the monopiles, while the OWTs seem not to have a significant effect on the WECs’ power efficiency.

Keywords

co-located wind-wave farm; hydrodynamic interactions; absorbed power; wave direction wave farm configuration
RESRB2017.0021

**Electrical response of thermoelectric generator module to transient thermal boundary conditions**

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**Abstract**

Some special features like having no moving parts and long life time, being highly reliable and environmentally friendly and silent operation make thermoelectric modules a good alternative energy technology to decrease dependency on fossil fuels. Typically, in many of renewable applications the operation boundary condition is not steady state but transient. Studying of transient condition helps us to investigate system response to more realistic boundary conditions. In this study transient behaviour of thermoelectric generator module is investigated both experimentally and numerically. Experimental study has been done for different boundary conditions in hot side and cold side of thermoelectric generator. Different heat sinks with various geometries and dissimilar working fluid have been implemented. Numerical investigation is carried out by using a numerical simulation approach with MATLAB software. The governing equations for thermoelectric generator in transient state are derived. Finite element method is used for discretizing the equations. The results are consisting of the variation of the temperatures, power generation and efficiency of the TEG with the time in the transient condition. Voltage-current and electrical power-current curves are presented and discussed for a vast range of electrical loads.

**Keywords**

thermoelectric generator; transient response; experimental and numerical study

**Acknowledgments**

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Coordinated reactive power compensation strategy for doubly-fed induction generation wind turbines

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Abstract

Wind energy sector has gained the highest attention among all other renewable energy resources. The UK government has a target of 15% of its energy to be produced from renewable sources [1]. In 2016 wind energy contributed up to 10% to the UK’s total electricity supply [2].

Over the last 30 years wind technology has improved, and various wind turbine concepts and generators have been developed and enhanced. The increasing use of wind energy in the UK grid imposed the requirements for wind farms to comply with current Grid Codes as conventional power plants and contribute to the network support and operation. The future of the large scale wind farms may lay offshore and comprehensive studies in terms of controllability and reliability are required [3, 4].

Nowadays the leading generator technologies in large wind turbine development are the double-fed induction generators (DFIG) and the fully rated converter (FRC) [5]. From the controlled development point of view, both technologies share the same mechanical system dynamics, and similar controllers can be applied to each technology to attain control over the speed of the turbine. However, during AC faults, the dynamics of each wind turbine technology are different due to the distinct fault response nature of each machine as well as the different type of power conversion interface to the ac grid.

During a fault condition the power electronics of the DFIG wind turbine are disconnected in order to protect partially-rated converter and control over the machine is lost. The DFIG also acts as an induction generator and consumes reactive power which does not comply with fault ride through capabilities.

This work analyses the behavior of the DFIG and FRC under voltage dip. The two technologies are combined into a hybrid wind plant and a control method is proposed to support DFIG wind turbine during voltage dip by providing reactive power via FRC wind turbine. Fig. 1 shows simplified power system configuration of hybrid wind farm.

Keywords
hybrid network; reactive power compensation; wind farm; voltage control

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Second life of lithium-ion batteries for supporting renewables: technical opportunities and challenges

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Abstract
Residential battery installations are slowly becoming a new market for energy storage systems. They are not only able to increase residential photovoltaic energy self-consumption, but they have also a potential to support low-voltage grid stability and reliability (e.g. voltage issues, harmonics, deferring low-voltage grid reinforcements), efficiency (less need for lossy energy transmission).

However, despite price falls, lithium-ion based battery systems are still too expensive solutions for residential battery installations but they are relatively close to achieving grid parity (estimated to be 0.2 €/kWh on the German market). Thus, in this work, other business model based on electric vehicle retired second life batteries will be investigated from the technical point of view.

The sale of electric vehicles is increasing recently, driven by environmental (pollution and CO₂ reduction) and political aspects (independence from fossil fuels delivery and energy self-sufficiency in the transportation sector). In consequence, the number of available electric vehicle retired lithium-ion battery packs will be increasing on the market. These inexpensive second life batteries do not have enough capacity to assure required driving range, but they still have a lot of lifetime (both calendar and cycle) left and they have potential to be reused in less demanding second life applications (e.g. supporting renewables).

Second life usage of vehicle retired batteries brings many benefits like environmental impact, cost reduction both in the first and second life application. However, there are also challenges related to the uncertainty of battery lifetime and safety.

In this work, a comprehensive technical state of the art will be presented in regards to second life usage of the lithium-ion batteries. The most important advantages will be presented but the focus will be on challenges related to the lifetime prediction of the second life batteries and safety aspects like lithium plating, gassing.

Keywords
lithium-ion batteries; second life; residential applications; safety
Syngas production by means of biogas recovery in the presence of mixed Ni-Co-Mg-Al oxides

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Abstract
Every day, human activity produces about 10 million tons of waste (excluding agriculture and construction), which represents a worldwide production of about 4 billion tons of waste per year. Nowadays, efforts are concentrated on the treatment of waste all over the world. Our study focuses on the energy recovery of the fermentable fraction of waste. Indeed, organic matter decomposes in the absence of oxygen and simultaneously produces biogas and a digestate which can be used as compost. One of the emerging technologies is to upgrade CH₄ and CO₂, the two major components of biogas. This is the dry reforming reaction of methane (DRM) (CH₄ + CO₂ → 2 CO + 2 H₂), which is particularly interesting, since it makes possible to produce a synthesis gas with a H₂/CO ratio close to 1, advantageous for several industrial applications, and to get rid of two greenhouse gases, which is a very important point because of global warming problems related to pollution. However, due to its endothermic nature, the DRM requires the use of a catalyst, to avoid going to very high temperatures and to observe sufficient conversions. Moreover, the DRM is accompanied by secondary reactions, some of which lead to the formation of carbon. In this context, efforts have been directed towards the development of catalytic systems with good activity and good resistance against carbon deposition. In this work, mixed oxides of Co, Ni, Mg, and Al were prepared using the hydrotalcite route, in order to obtain interesting catalytic properties. The prepared systems were characterized by different physicochemical techniques and tested in the DRM. In addition, real biogas samples were analyzed at two biomethanation centers, one in France and the other in Lebanon. Thus, knowing the identity and the quantity of the various compounds, a study of their effect on the efficiency of the catalyst will be done. Our results show that the real biogas is composed, besides the major components CH₄ and CO₂, of NH₃, H₂S, some terpenes and some VOCs... Our catalysts were tested in the DRM using a mixture of CH₄:CO₂ (1:1). The Co-Ni based system seems to be the best system joining the high activity of nickel with the high resistance of cobalt towards carbon deposition. The evaluation of the catalytic performances in the presence of some impurities that exist in biogas such as volatile organic compounds (toluene) is also a part of this work.

Keywords
biogas; hydrotalcite; dry reforming of methane; cobalt; nickel; carbon formation

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Efficiency and battery impact of the commercial fast charging stations

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Abstract

Although Li-ion batteries can be charged faster than other battery chemistries, the long charging time still becomes one of the main disadvantages of the electric vehicles (EVs). The shape and quality of battery charging profile are very important because it influences not only the battery charging time but also battery lifetime, safety and reliability.

A battery cannot accept an infinite high charging current as the chemical reactions provide a certain limitation. The charges should therefore not be “pushed” into the battery faster than the battery can react to the charges. The chemical conversions during the charge have different dynamics and can be divided into charge transfer, mass transport, and intercalation process [1].

Many different fast charging methods for Li-ion batteries were studied in the literature [2-10]. These methods modify the conventional constant current/constant voltage approach by applying e.g. negative (discharging) pulses, multiple CC stages or superimposing an AC signal. These methods aim to minimize charging time and temperature rise and to maximize the charging energy while keeping each cell’s current and terminal voltage inside a predefined safe operating area (SOA).

Figure 1 and Figure 2 present the charging voltage and current (from grid side) in function of time during the Nissan Leaf fast charging method with a commercial charger.

In this work, the fast charging method for the Nissan Leaf Li-ion battery pack will be investigated with respect to charging time and charging efficiency. The fast charging strategies will be compared with typical home electrical outlet slow charging method. The impact of the fast charging algorithms on battery pack will be investigated by analyzing battery pack individual cells charging characteristics.


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Keywords
lithium-ion batteries; fast charging; electromobility
Electrochemical behaviors of steam-activated activated carbon by polymeric precursor

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Abstract
Supercapacitors are very attractive as a potential energy storage system because of their high energy density, quick charge-discharge rate, low cost, and maintenance-free long life operation. Carbon materials with high specific surface area, such as activated carbon, activated carbon fiber cloth, and carbon aerogels/foams are usually used as electrode materials of electrochemical capacitors.
In this study, ACs were prepared for supercapacitor electrode applications by using polymeric precursor under various steam activation conditions. The N₂ adsorption isotherm characteristics at 77K were confirmed by BET and DR equations. ACs processed at various activation condition were applied as electrodes for electrical double-layer capacitors. From the results, specific surface areas and total pore volume of the ACs were determined as 1200~2400 m²/g and 0.53~1.22 cm³/g, respectively. It was also observed that various pore size distributions were found to be depended on the functions of activation time and temperature. The ACs were applied as an electrode for EDLCs and analyzed in relation to the activation conditions.

Keywords
hard carbon; steam activation; polymeric precursor; supercapacitor
RESRB2017.0027

Electrochemical evaluation of alloy degradation in molten salt for thermal energy storage in CSP: case study of A36, AISI 304 and 316

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Abstract
The implementation of solar-based generation of electricity is of particular strategic importance in Chile, where the direct normal irradiance is one of the highest in the world and concentrated solar power (CSP) has been the technology of choice in the recent commissioning. In this system, round-the-clock power generation relies on the storage of thermal energy in molten salt. Considering the operational temperatures of 290-550 °C in case of commercial nitrate salts, integrity of the storage system might be compromised due to electrolytic nature of the salt possibly producing uniform and/or localized corrosion. The aim of this research is the development of a corrosion monitoring technique focused on Thermal Energy Storage (TES) materials and based on Electrochemical Impedance Spectroscopy (EIS) for control storage systems.

In this work we present an electrochemical approach for laboratory evaluation of corrosion rate as well as estimation of the likelihood of localized corrosion to set in. The case of one carbon steel (A36) and two stainless grades (AISI 304 and 316) employed in different types of nitrate-based molten salts, commercial and experimental, is considered. The results of predicted corrosion rate are validated with data of weight loss obtained from long term exposure at simulated process conditions.

Keywords
concentrated solar power (CSP); thermal energy storage (TES); corrosion, molten salts

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Biodiesel synthesis by transesterification of high acidity fats pig

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Abstract
Pig fats of high acidity have been transesterified with the purpose to synthesize methyl esters (biodiesel) to replace diesel oil. This work, in consonance with the use of renewable sources of energy, wants to make use of a residue without industrial application and that, on the other hand, can originate environmental problems. Methanol/fat molar ratio (3:1 to 12:1), catalyst type (KOH, MeONa and MeOK), catalyst concentration (0.5 to 1.5 %) and temperature (40 to 65 ºC) were studied as variables of the process. Previously, fats were treated with sulfuric acid and methanol to esterify the free fatty acids.

The concentration of the methyl esters of the palmitic, stearic, oleic and linoleic acids was determined by chromatography. These acids constituted 95 % of the total fatty acids in the pig fats. The final biodiesel was characterized determining density, viscosity, flash and combustion points, cold filter plugging point (CFPP)), saponification and iodine values, Conradson residue, characteristics of distillation, cetane value, higher heating value (HHV) and acidity index.

The majority ester is the oleate (50 %), followed for the palmitate (25 %), linoleate (12 %) and stearate (10 %). Also are detected, although in small amounts, esters of the myristic, palmitoleic, linolenic, gadoleic and erucic acids. Kinetically, the reaction is very fast, being obtained conversions next to the full in times of 15 to 20 min. After this fast initial period, there is a second period, much longer, in which concentration evolves slowly even to achieve the value corresponding to equilibrium.

The methanol/fats molar ratio exert a large influence on the methyl esters yield. The 9:1 molar ratio leads to the best results. The maximum yields of methyl esters obtained with the different catalysts were 95 % with KOH, 91 % with MeONa and 89 % with MeOK. The very best concentration of catalyst was 1 %, even though the results obtained with 1.5 % were very similar. At last, the most idoneous temperature was 65 ºC. Nevertheless, the process also takes place to adequate rates when temperature is near to ambient (40 and 50 ºC).

The final product is comparable to a diesel of motorization. That way, density (850 kg/m3), viscosity (5.38 cSt to 40 ºC), HHV (39.4 MJ/kg), cetane value (50) and Conradson residue (0.017 %) present similar values. The CFPP has a value of 4 ºC, very superior to the a diesel oil, what constitutes an inconvenience in cold climates. On the contrary, flash and combustion points (185-198 ºC) are very superior to the diesel oil (85 ºC), what represents an advantage from the point of view of handling and storage.

Keywords
biodiesel; transesterification; pig fats; basic catalyst; high free acidity
Impact of alternative fuels produced from municipal waste (SRF) on the fire-explosive properties of primary fuels during co-combustion of fuel mixtures

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Abstract
Municipal waste is a renewable energy source, because it can be recycled into a so-called secondary fuel SRF (solid recovered fuels), which can subsequently be co-incinerated in the power industry with fossil fuels. The incineration of SRF not only helps to reduce landfill waste by disposing of waste, but also by extracting energy from cheap sources such as waste and saving fossil fuels. The subject of this paper is the analysis of the impact of fuels produced from municipal waste on the fire-explosive properties of the primary fuels. Two SRF fuels different in their biomass and plastic fractions were selected. These fuels were co-incinerated in mixtures with hard coal and lignite. For comparison, the effect of sewage sludge on the co-firing process with the fossil fuels was also explored. Based on the conducted experiments, it was found that from 5 to 10 % mass fraction of SRF in hard coal or lignite mixture did not significantly change the fire-explosive properties of the base fuel. This suggests that SRF fuels do not significantly increase the risk of unwanted ignition or explosion.

Keywords
renewable energy sources; SRF; combustion; co-firing; fire and explosion hazards

Acknowledgments
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Comparative analysis of Hybrid Power Systems based on Homer and iHOGA simulators

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Abstract
A study for sizing a hybrid system based on renewable energy sources, using HOMER and iHOGA programs is presented in this paper. The hybrid system includes: photovoltaic panels, wind turbine, diesel generator (D.G.), battery, converter and electric load. A case study on the design of a system to supply a 160 W electric load was performed using HOMER software, and another two case studies, for the same load, were performed using iHOGA. The simulation results are presented both in tabulated and graphical form for a better visualization of the differences between them. The third case uses iHOGA program, and the hybrid system includes: photovoltaic panels, wind turbine, battery, converter and electric charge without D.G.. The third case is made only in iHOGA program because the equipment chosen has an increased reliability (especially storage elements and power converters) in comparison with those chosen by the HOMER program. A comparative analysis was made, showing the pros and cons of each software, in order to allow the investor to choose the most convenient design.

Simulation results show: in iHOGA program the share of renewable energies is higher, having the value of 92%, in comparison to HOMER program which provides a renewable energy share of 81%. The contribution provided by both programs for energy production by sources stays in the same order: photovoltaic panels (78.86% - iHOGA, 58.63% - HOMER), wind turbine (15.24% - iHOGA, 27.45% - HOMER), diesel generator (5.89% - iHOGA, 13.92% - HOMER). The cost of energy (COE) supplied by the HOMER program is with 2.6% more expensive than the cost of energy supplied by the iHOGA program. Net present cost (NPC) obtained by the HOMER program is with 82% lower than the net present cost obtained by iHOGA program. The initial capital supplied by the iHOGA program is with 47.6% higher than the initial capital supplied by HOMER.

Calculation of costs using iHOGA program indicates an increased cost for the: storage elements as well as converters, energy sources having lower prices. In contrary at HOMER program the higher prices correspond to the energy sources and the lower ones to the other components.

The HOMER program can perform optimal sizing with all renewable sources along with diesel generators, battery and load, performing both technical and economic analysis of the system. Disadvantages: high relative calculation times, ca not perform multi-objective optimization as the only objective is minimizing the NPC.

iHOGA program presents the following advantages: the models are more accurate than in HOMER program, the calculation times are low, it can perform multi-objective problems, and also technical and economic analysis. Control strategies are more complex than in Homer program. iHOGA uses genetic algorithms to study the costs and polluting emissions, for determining of the report, for the number and type of components (solar panels, wind turbines, batteries and AC generators). The main disadvantage is that it cannot perform probability analysis.

Keywords
hybrid power system (HPS); Hybrid Optimization of Multiple Energy Resources (HOMER); improved Hybrid Optimization by Genetic Algorithms (iHOGA); net present cost (NPC); cost of electricity (COE)

Acknowledgments
Work under PhD stage, contract number: SD4/27/18.10.2013.
Glycerol steam reforming over Ru-Mg-Al hydrotalcites: role of the preparation method in catalytic activity

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Abstract
In recent years, environmental concerns associated with fossil fuel utilization have led to increased interest in the use of biofuels. By definition, biofuels are fuels derived from biomass sources which can not only act as an energy source but are also considered to be carbon neutral. Biodiesel in particular has received considerable attention as it is a promising renewable energy alternative. Biodiesel is mainly produced via the transesterification reaction of vegetable oils or animal fats with methanol. This reaction also produces glycerol as a by-product. With projected increases in the biodiesel industry, glycerol production is also expected to increase thereby resulting in huge quantities of unusable glycerol. A solution to this issue is to convert these quantities of glycerol to hydrogen via catalytic reactions. This work focuses on glycerol steam reforming (GSR) as a means of valorisation of glycerol. GSR is attractive because the reaction can theoretically produce 7 moles of hydrogen from 1 mole of glycerol. However, its endothermic nature necessitates the use of a catalyst. Hydrotalcite derived mixed oxides were chosen as the catalyst supports for this reaction as they exhibit several interesting properties including thermal stability, high surface areas, and small crystallite sizes after calcination. Ruthenium was chosen as an active phase as it is the least expensive amongst noble metals. Moreover, it is known to decrease catalytic deactivation caused by carbon deposition.
Ru-Mg-Al catalysts were prepared using two different methods of incorporating the ruthenium. The first method involves conventional wet impregnation whereby the active phase is loaded onto the support after calcination. The second method involves grafting whereby the active phase is added during the actual synthesis step of the support. The prepared systems were then characterized by various physicochemical techniques (XRD, BET, TPR...) and tested in the GSR reaction in order to evaluate the role of the preparation method on catalytic activity. For comparison, an Mg-Al catalyst was also tested to understand the effect of ruthenium addition. It was found that the preparation method does indeed play a role as it controls the accessibility of the active phase (Ru) which is mainly responsible for the catalytic activity. The significance and novelty of this research work lies in the use of hydrotalcites as precursors of catalyst supports for GSR and the incorporation of a relatively cheaper noble metal using two different preparation methods for the production of hydrogen from glycerol.

Keywords
glycerol; hydrotalcite; hydrogen; ruthenium
Towards more sustainable practices on HTC. Wet oxygen treatment of liquid phase

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Abstract
Despite hydrothermal carbonization (HTC) has been consolidated as a promising and purposeful technique to upgrade biomass wastes and provide carbon materials suitable for many applications (solid biofuels, adsorbents, electrode materials, soil remediation, etc.) [1] some knowledge gaps have to be tackled in order to catalyze the real implementation of this methodology at large scale.

One of the most important handicaps towards its industrial implementation stands on the properties of the liquid phase (LP). While this phase can be regarded as a source of valuable chemicals (such as hydroxymethylfurfural HMF), the presence of some N-organic compounds, potentially harmful to the environment, makes HTC less sustainable and adds complexity to by-products handling. Moreover, previous pieces of research have already given evidence about the convenience of focussing on LP nutrient value, which might be used to guarantee a “nutrient recycling concept”, using the liquid phase as growing medium for specific biomasses such as microalgae [2]. It is therefore a priority to investigate ways of improving liquid phase composition not only to solve their disposal but also to take profit of its applicability. Within this frame, this work focussed on the HTC of microalgae (0.15 L Berghoff autoclave, experimental details given elsewhere [3]) under different conditions, and the study of N distribution between liquid and solid phases, as well as the improvement of LP composition after in-situ wet oxygen treatment.

The results obtained showed that microalgae Scenedesmus sp. can be successfully converted into functional hydrochars, which can have a different composition, thermal behaviour, and energy content, depending on the experimental conditions used. Wet oxidation is a suitable treatment to decrease the quantity of N compounds on the liquid phase, as well as to remove organic compounds; especially if oxygen diffusivity is enhanced by using greater temperatures. Abundant valuable carboxylic acids were identified by liquid chromatography such as oxalic, malonic, acetic, succinic, citric, acrylic acid, propionic and butyric acids; in general, these compounds decreased their concentration after the treatment, because of their conversion into simpler, more easily biodegradable species.


Keywords
hydrocarbonization, biomass, liquid phase, wet oxygen treatment

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The authors are grateful to the funding support by “Ministerio de Economía y Competitividad”, Spanish Government for financial help through project CTM2014-55998-R and CTM2016-75937-R.
Retrospective analysis of bioenergy development in Poland: lessons for the sustainable bioeconomy sector

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Abstract
Bioenergy production, including transportation biofuels, is a main contributor to the renewable energy sector in Poland, amounting at over 80% of total primary energy production from renewable sources including heat, power and transportation biofuel. The bioenergy deployment has been stimulated by the supportive policies and public acceptance for green energy. However, over time many unintended negative consequences received considerable attention. Lessons learned from bioenergy and biofuels should be taken into account in the future, in particular when new sustainable bio-based sectors are established.

Since over a decade when Poland joined the European Union, it is a momentum to review and summarize the bioenergy deployment in Poland with regard to implications and challenges for the future. We provide an in-depth analysis of the bioenergy system in Poland integrating policy, support measures, resources, technologies, key actors, and relevant environmental, economic and social aspects. In our paper focus is given to the objectives and the anticipated outcomes as well as site-effects that could be linked to the development of bioenergy in Poland. The main lessons learned from the development of bioenergy sector in Poland are: (i) a stable and long-term support policy should be set, preferably in a form of a dedicated strategy, (ii) the strategy must be accompanied with a clear vision on the resources that will be utilized and the sectors and technologies involved, (iii) the choice of policy instruments strongly determines the shape of the sector in terms of the winning technologies, (iv) the sustainability of biomass production and use must be ensured for all competing biomass technologies and end-uses, (v) in a long-time a refocus on biomass use is desired from mainly energy applications (fuel) to chemicals and material applications to ensure optimal use of biomass. Additionally, we made some qualitative judgment to identify crucial choices and decisions in Poland that led to unintended negative site-effects, and on the other hand those that have to be made to stimulate the future development of sustainable bioenergy in Poland.

The implications of the bioenergy deployment in Poland could be very essential for the future development of sustainable bioenergy and other bio-based industries driven by the sustainable bioeconomy concept adopted as a new strategy for the European Union. Forthwith, the lessons learned might be applied when national and regional bioeconomy strategies will be developed in Poland, and possibly useful for other countries.

Keywords
bioenergy; biofuels; bioeconomy; sustainability; site-effects
Influence of acetate as a sole carbon source to enhance biological phosphorus removal

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Abstract
Enhanced biological phosphorus removal (EBPR) is a popular treatment for biological wastewater treatment systems. It can remove not only carbon but also nitrogen and phosphorus simultaneously. Phosphorus accumulating organisms (PAOs) play a significant role in releasing and uptaking phosphorus in various phases of the EBPR process. It relies on specific carbon source to phosphorus (P) ratio. This aim of research is to investigate the effectiveness of acetate as a sole carbon source to PAOs kinetics.

There are 3 phases included in the EBPR processes; anaerobic, anoxic and aerobic conditions, respectively. Synthetic wastewater preparation relied on chemical oxygen demand to phosphorus (COD/P) ratio. It was presented at 20. Hydraulic retention time for anaerobic, anoxic and aerobic conditions have controlled at 2, 2 and 8 hours, respectively. Retention time was carried out for 20 days. Experimental results are shown in the following Table 1.

Table 1. Efficiency on EBPR processes for acetate applied as a carbon source.

<table>
<thead>
<tr>
<th>Item</th>
<th>influent (mg/L)</th>
<th>Anaerobic (mg/L)</th>
<th>anoxic (mg/L)</th>
<th>aerobic (mg/L)</th>
<th>effluent (mg/L)</th>
<th>%removal</th>
</tr>
</thead>
<tbody>
<tr>
<td>PO₄³⁻</td>
<td>23.54±1</td>
<td>29.93±10</td>
<td>11.82±5</td>
<td>5.63±4</td>
<td>4.38±2</td>
<td>87.97%</td>
</tr>
<tr>
<td>COD</td>
<td>500±9</td>
<td>57±40</td>
<td>21±10</td>
<td>18±14</td>
<td>4±7</td>
<td>100%</td>
</tr>
<tr>
<td>TKN</td>
<td>14.90±1</td>
<td>-</td>
<td>-</td>
<td>0.17±0.07</td>
<td>99.00%</td>
<td></td>
</tr>
<tr>
<td>NH₃</td>
<td>14.85±0.8</td>
<td>-</td>
<td>-</td>
<td>0.06±0.05</td>
<td>100%</td>
<td></td>
</tr>
<tr>
<td>NO₂⁻</td>
<td>-</td>
<td>0</td>
<td>0±0.01</td>
<td>0</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NO₃⁻</td>
<td>-</td>
<td>0.04±0.01</td>
<td>0.01±0.05</td>
<td>0.05±0.01</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Experimental results, in Table 1, demonstrated that the high COD removal under aerobic conditions was between 70% and 100%. Besides, mixed liquor suspended solids (MLSS) maintained at 4,370 mg/L. High efficiency of phosphorus removal, TKN and NH₃ expressed up to 99%, 99%, and 100%, respectively. This is due to PAOs can efficiently release and take up phosphorus under anaerobic conditions, and anoxic and aerobic conditions, respectively.

This acetate supplement is suitable for the growth of PAOs. Because acetate is high up taken under anaerobic conditions. Because, under anoxic and aerobic condition PAOs can utilize phosphorus and store internally as polyhydroxyalkanoates (PHAs). As a result, an efficiency of phosphorus removal is approached almost 88%. In addition, C and N can remove almost 100%.

Keywords
acetate; COD; EBPR; phosphorus accumulating organisms; phosphorus

Acknowledgments
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RESRB2017.0035

Pruning residues from agriculture - harvesting, potential and practice in Europe

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Abstract
Pruning residues from agricultural activity in plantations and orchards might be an additional and significant biomass resource in Europe. However, this type of biomass in terms of its use for energetic purposes is still not well recognised. Especially, there is not much data about national potentials of this kind of biomass according to the species and size distribution, which influence the harvesting, productivity and further treatment. EuroPruning project has carried out a study of the current status of agricultural pruning in Europe. In the current work the management of pruning residues is described. The impact of the size distribution of farms (fruit, citrus, nuts, olive, vineyard) on the pruning-to-energy (PtE) value chain is examined. It has been found that the size distribution of plantations and orchards is differentiated for different species and countries. In Europe, farms larger than 5 ha cover 72.78% of the total plantations and orchards area. Whereas, the small farms (less than 2 ha) and medium size farms (from 2 to 5 ha) contribute with 11.67% and 15.54% area, respectively. Large farms are associated with nuts (80.21%) and vineyards (79.65%) productions. It suggests, that there is a large potential for professional and mechanised harvesting of pruned biomass benefiting from the economy of scale.

Keywords
agricultural residues; orchards; pruning; potential; size distribution
Contribution of chemical storage to the future energy networks

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Abstract
The large adoption of renewable energy is crucial to meet the long-term objective of CO2 neutrality by 2100. The integration of renewables will lead to a huge need in electricity storage at different time scales. Indeed, in order to have a continuous electricity supply, even when wind turbines and photovoltaic panels do not produce sufficiently, energy storage becomes one of the crucial parameters of the grid. Different forms of storage are currently available, with different characteristics and degrees of maturity. One of the promising options is the chemical storage.

The principle of the chemical storage is to use excess electricity, to produce hydrogen by electrolysis of water. Hydrogen can then be stored directly or further converted into methane (CH4 from methanation if CO2 is available, e.g. from a carbon capture facility), methanol (CH3OH again if CO2 is available), and/or ammonia (NH3 by an electrochemical process). These different fuels are stored in a liquid or gaseous form, and thus with different energy densities, according to their physical and chemical natures. In times of electrical shortage, these chemical compounds are then used for the production of electricity and heat.

This project aims at optimizing, at the level of a residential city district, the production, the storage and the use of these different fuels derived from renewable electricity with a focus on the storage sizing and on the efficient restitution through combined heat and power facilities. In this study, different scenarios are proposed and optimal chemical storage solutions are proposed. In each scenario, the energy costs for the production of each fuel, for the storage and for the restitution into electrical energy are considered. This applied study on chemical storage underlines that the combination of these fuels can sustain a large part of all the electric needs of a district.

Keywords
chemistry; storage; hydrogen; methane; ammonia; methanol
RESRB2017.0037

The role of hydrogen storage as central flexibility option to reach 100% renewable cover rate in the European power system in 2050

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Abstract

Today many publications show that a future European energy system based on high shares of renewable energy sources (RES) is feasible. However, for very high renewable cover rates close to 100%, the technical effort necessary to ensure a temporally resolved electricity supply, increases drastically. This increase is both in terms of installed generation capacity and in flexibility options. Especially hydrogen storage is known to come into play only when a renewable share >80% - 90% is targeted. Its technical potential is promising, yet high losses in the re-electrification lead to low efficiency and thus increased demand of RES-capacities.

Looking at a European scale energy system, the distribution and technical versatility of RES-capacities has a strong influence on the regional flexibility demand and thus on the overall security of supply. This work shows how two different energy scenarios for the European power system in 2050, each with a different technology focus (wind energy and solar power), perform in terms of needed flexibility options and utilization of their technical potentials.

Therefore the RESTORE-model is used, which is an optimisation-based dispatch model of the European power system, featuring 32 countries, an NTC-based transmission grid and hourly feed-in of eight renewable flexible and fluctuating technologies. The model also accounts for the regional technical potential of storage systems such as pumped hydro, hydrogen and compressed air energy storage and calculates the hourly dispatch of each system component for a chosen weather year. In contrast to many existing energy system models, the optimisation focuses on energy efficiency and reduction of peak residual loads. Together with the high level of detail of the addressed system, this makes the model unique in this field of research.

By performing multiple simulations with increasing RES-capacities for each of the two scenarios, the results show effects of the varying technology focus on the utilization of storage and distribution infrastructure. By analysing key system parameters such as renewable cover rate, redispatch and residual energy demand, we can draw conclusions about the interdependencies of technology focus, security of supply and the role of hydrogen storage. Finally, the work points out the added value of a joint European energy strategy and serves as a decision basis for policy makers.

Keywords

renewable energy; flexibility options; Europe; 2050; modelling
Investigation of treatment and assessment options with determining methane gas potential: a case study

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Abstract
Izmir has been one of the cities in our country which firstly began to implement a regular solid waste disposal system with the operation of Harmandali Landfill Facility in 1992. An important part of municipal solid waste produced in contiguous area of Izmir during the period of 25 years was disposed in this facility in order to minimize any possible problems on health and environment caused from that solid waste.

The most important factor for deciding on the energy potential of landfill is the amount of landfill methane gas in the landfill area. There are several approaches used to determine the amount of landfill gas. We use five different methods and one literature-based approximate forecast to determine the amount of the landfill gas in Harmandali Landfill. The methods are (i) Tabasaran/Rettenberger, (ii) Multi-Phase, (iii) LandGEM, (iv) Scholl Canyon and (v) IPCC 2006.

The main objective of this study is to investigate the use of landfill gas as potential energy and electricity provided from municipal solid waste (domestic, industrial, medical waste and sewage sludge) stored regularly in Harmandali Solid Waste Landfill Area, within the boundaries of the contiguous area of Izmir.

Keywords
landfill; solid waste; landfill gas; methane

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I would like to extend my gratitude to the Izmir Mega Municipality staff and managers for making it possible for me to be informed in this study.
RESRB2017.0039

Increasing efficiency of biogas Cassava pulp with pre-treatment

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Abstract
Starch and lignocellulose are main cassava pulp components. This lignocellulose affects decreasing biogas. Pre-treatment can break chemical bond of cassava pulp easily. It can convert cassava pulp to glucose or reducing sugar, and volatile fatty acid (VFAs). In this study, the pre-treatment includes pH, temperature, and time reaction. Its application aims to enhance cassava pulp biogas, CH₄ volume as well as CH₄ percentage. This could reduce controlling cost and enhance profit. Method is carried on to observe 2 issues. First, it is to find out optimum conditions of pH, temperature and time reaction as a pre-treatment process. The pH is adjusted to 0, 2, and 4. Then, it is heated at 40, 50, 60 and 100 °C for each of 30, 60 and 90 minutes. This is to approach the highest value of reducing sugar and VFAs. Two conditions have been chosen from first experimental series based on high value of reducing sugar and VFAs. Second, it is to investigate biogas, CH₄ volume as well as CH₄ percentage (Table 1). They have been represented as a tested set. Besides, non-pH adjusting is a controlled set. Its pH is between 4.36 and 4.38.

There are two conditions chosen for the test set. First, the second highest reducing sugar value is 542.5 mg/g dried weight. Second, the fourth highest reducing sugar is 339.5 mg/g dried weight. Both conditions controlled with similar condition of temperature and time reaction which are 100 °C and 30 minutes, respectively. Except pH are 0 and 2 for first and second value, respectively. Both of them chosen, it is because of consumes smaller energy in comparison with others of slightly different value of reducing sugar. Overall experiments, VFAs are less significant of different amount.

Table 1. Biogas and CH₄ and CH₄ percentage observed at various days.

<table>
<thead>
<tr>
<th>Time (day)</th>
<th>Biogas (m³/kg TVS)</th>
<th>CH₄ (m³/kg TVS)</th>
<th>% CH₄</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crl. pH 0 pH 2</td>
<td>Crl. pH 0 pH 2</td>
<td>Crl. pH 0 pH 2</td>
</tr>
<tr>
<td>7</td>
<td>0.02 0.02 0.07</td>
<td>0.01 0.01 0.04</td>
<td>37.90 53.00 66.00</td>
</tr>
<tr>
<td>14</td>
<td>0.04 0.03 0.10</td>
<td>0.02 0.02 0.07</td>
<td>42.10 60.50 72.00</td>
</tr>
<tr>
<td>21</td>
<td>0.07 0.04 0.14</td>
<td>0.03 0.02 0.09</td>
<td>60.00 63.00 75.30</td>
</tr>
<tr>
<td>30</td>
<td>0.09 0.05 0.18</td>
<td>0.05 0.03 0.13</td>
<td>60.00 66.00 78.00</td>
</tr>
</tbody>
</table>

Those two test set and control set have controlled under anaerobic conditions during observation up to 30 days. As shown in Table 1, 0.18 m³/kg TVS and 0.13 m³/kg TVS are the highest biogas and CH₄, respectively. It is applied at pH 2, 100 °C for 30 minutes. Also, CH₄ percentage is 2.6 times higher than control. Addition, its result shows 78% of CH₄ generated the highest value in comparison to others. Also, an application for control processes to approach maximum benefit relies on specific cassava pulp composition.

Keywords
biogas; Cassava pulp; methane; pre-treatment; reducing sugar
Influence of silica gel and lipopeptide biosurfactant on methane hydrate kinetics

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Abstract
Natural gas hydrates are white crystal like compounds formed under suitable temperature and pressure in the presence of water and former gases like methane, ethane, CO2. Gas hydrates has potential to serve human society as an alternative future energy resource. However, slow rate of gas hydrates formation limit its extensive application. The present study examines the feasibility of using combination of biosurfactant and porous fixed bed system as methane hydrate formation promoter. Porous fixed bed system consisted of C type silica gel. Biosurfactant used in the study was produced by rhizospheric bacteria Bacillus subtilis strain A21. With help of analytical techniques purified biosurfactant was characterized as lipopeptides type microbial surfactant. Silica gel saturated with surfactin solution increased the number of moles of methane consumed during hydrate formation. Presence of surfactin solution in silica gel reduced the induction time significantly. The rate of methane consumption also increased in the presence of surfactin solution. Overall gas consumption also increased in the system consisting combination of surfactin solution and silica gel. Results suggest that surfactin in combination with silica gel can act as environment friendly gas hydrate promoter.

Keywords
fixed bed; lipopeptide; induction time; surfactin; natural gas hydrates

Acknowledgments
The support provided by sending Mr. Amit Arora on study leave from Shaheed Bhagat Singh State Technical Campus, Ferozepur to Indian Institute of Technology Roorkee is highly acknowledged. The support from institute namely Indian Institute of Technology, Uttarakhand, Roorkee, National Chemical Laboratory (CSIR lab), Maharashtra, Pune, India, Institute of Microbial Technology (CSIR Lab), UT, Chandigarh, India, Keshav Dev Malviya Institute of Petroleum Exploration, Oil and Natural Gas Corporation (ONGC), Uttrakhand, Dehradun, India ,and Indian School of Mines, Jharkhand, Dhanbad, India, Indian Institute of Technology, Roorkee, India, Gas Hydrate Research & Technology Centre,Oil and Natural Gas Corporation Ltd (ONGC) ONGC Complex Phase-II, Panvel, Navi Mumbai - 410221, India and Indian Institute of Technology, Chennai is highly acknowledged.
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Analog model of a flat plate solar collector dynamics for use in control algorithms

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Abstract
The research consists of development of flat plate solar collector's analog model. The solar collector was presented as a two terminal pair network using the equivalent thermal network method. The result of that solution was the transfer function describing the relationship between input/output signals. Model was verified using the commonly used digital model.

The analog model defines collector’s dynamic operating range with its design and operating parameters. This allows to simulate parameters changes, i.e. the thickness of the glass cover, the thickness of the absorber, the diameter of the flow channels and the flow velocity of the working medium. By examining the step responses, the impact of solar collector’s design and operating parameters on its dynamic operating range was analyzed.

The main conclusion of the research is the fact that now it is certain that it is possible the modelling and analysis the dynamic operating range of solar collector at the stage of its design. According to the research it becomes possible to choose the best group of the design parameters that will ensure appropriate course of its dynamic states. It can guarantee minimum quickly fading oscillations (for example “thermal shock”). This gives the ability to choose the control method for solar heating system, tuning its regulators.

The essential value of the work is to apply an integrated approach from two different areas of science: energetics and automatics. The test object was a flat plate solar collector which is, nowadays, the most common device used in solar systems from the renewable energy field.

Keywords
solar collector; equivalent thermal network; analog model; control of solar heating systems
Identification of kinetic parameters for CO$_2$ hydrogenation to hydrocarbons by differential evolution (DE) strategy

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Abstract

In current research, differential evolution (DE) strategy has been applied in order to identify kinetic constants for the CO$_2$ hydrogenation to hydrocarbon (Modified Fischer-Tropsch synthesis). A mathematical steady-state modeling framework for Modified Fischer-Tropsch synthesis in a micro reactor was developed, and the comparative performance of the theoretical reactor (TR) and experimental reactor (ER) versus reactor length was accordingly investigated. In all simulation runs, the proposed TR model was utilized for the reactor operating conditions such as temperature 300 °C, pressure 1 MPa, H$_2$/CO$_2$ ratio 3. A detailed benchmarking suggested that the models developed in the present study predicted total CO$_2$ conversion levels of 34.2% which was higher than the experimental values reported 33%. Furthermore it was observed that the TR configuration not only increased CO$_2$ conversion but also produced more hydrocarbon (i.e C$_3$H$_6$) consequently the C$_3$H$_6$ produced in terms of mol/mol feed*100 in TR was 0.031 which also was higher than the one in ER 0.029. The difference between theoretical and experimental outlet at length of 60 cm was due to the increase of shell surface area in the theoretical model. In addition, while the experimental only presented the final results of reactor, the theoretical has predicted the progress trajectory of each reactant and product along the reactor.

Keywords
differential evolution; hydrogenation
Enhanced anaerobic digestion by using solid-state and temperature-phased digesters - opportunities and challenges

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Abstract
Anaerobic digestion (AD) is a multi-purpose technology applied for processing organic feedstocks, including biowastes, into sustainable biofuels and a range of other products. Nevertheless, state-of-the-art liquid AD (LAD) suffers from several technical, economic and environmental challenges. Therefore, solutions targeting at AD enhancement are urgently sought. This work analyzes how solid-state AD (SSAD) and temperature-phased AD (TPAD) can enhance state-of-the-art LAD. In SSAD solid feedstocks are hydrolyzed and leachate undergoes methanogenesis. In TPAD thermal phasing is used to separately optimize conditions in the phases. The number of publications on SSAD has grown rapidly since 2010 emphasizing increasing attention in this promising AD option. SSAD performance benefits from higher organic loading rate and reduced wastewater generation at relatively high methane generation rates. TPAD, due to thermal phasing, allows for utilizing optimized microbes and temperatures in the separated phases thereby improving a feedstock-to-methane conversion ratio. Both SSAD and TPAD, after further necessary refinement, might be able to process easily available and cheap feedstocks comprising lignocellulose.

Keywords
anaerobic digestion; temperature-phased; solid-state; research trend; enhancement

Acknowledgments
The support obtained from Wojciech Budzianowski Consulting Services under the project no. WBCS-RDG02/2017 is greatly acknowledged.
Critical effect of total solids on Cassava pulp biogas

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Abstract

Biogas production efficiencies in batch mode in which cassava pulp was treated by acid and base hydrolysis processes were compared. The experiment was divided into two parts at concentration of pulp 1.67% TS and 5% TS. First, optimum conditions for acid and base hydrolysis were evaluated by comparing yields, reducing sugars and volatile fatty acids. This experiment was run by using two level factorial design with 3 factors, i.e., pH, temperature and reaction time. Finally, effects of reducing sugar and volatile fatty acid concentrations on biogas production efficiency were investigated. The study found that pH and temperature were considered as the main factor significantly affecting on acid and base hydrolysis performances. For acid hydrolysis, the highest amount of 543 and 754 mg reducing sugars/g dried weight, 161 and 224 mg volatile fatty acids/g dried weight were observed at the condition of pH 0.38, temperature 100 °C and 30 minute reaction time. The concentration of cassava pulp was unchanged at 1.67% TS and 5% TS.

Table 1. Methane gas observed at various days.

<table>
<thead>
<tr>
<th>Time (day)</th>
<th>CH₄ (m³/kg TVS) at 1.67%TS</th>
<th>CH₄ (m³/kg TVS) at 5%TS</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Crl.(pH 4.23)  pH 0.38  pH 2</td>
<td>Crl.(pH 4.23)  pH 0.38  pH 2</td>
</tr>
<tr>
<td>7</td>
<td>0.0003 0.0003 0.0009</td>
<td>0.0219 0.0181 0.0392</td>
</tr>
<tr>
<td>14</td>
<td>0.0009 0.0009 0.0018</td>
<td>0.0454 0.0365 0.0973</td>
</tr>
<tr>
<td>21</td>
<td>0.0014 0.0015 0.0025</td>
<td>0.0705 0.0499 0.1353</td>
</tr>
<tr>
<td>30</td>
<td>0.0017 0.0024 0.0027</td>
<td>0.0900 0.0646 0.1757</td>
</tr>
</tbody>
</table>

Two different conditions for acid and base hydrolysis were selected from the first part. Biogas production systems were operated by using laboratory batch test units. Anaerobic digestion of the thin stillage also shown in Table 1. The maximum rate of biogas yield was found at the cassava pulp concentration of 1.67%TS and 5%TS. In the study, conditions of hydrolysis were at pH 2, Temp 100 °C, and 30 mints reaction time before fermentation. Cassava pulp of 5%TS produced biogas yield as high as 0.1757 m³/kg TVS. The conditions for the biogas digesters with 1.67%TS produced biogas yield as 0.0027 m³/kg TVS. In comparison to 1.67%TS, 5%TS produced with this extra yield, it can generate 65 times more liquid propane gas (LPG) and electricity. The concentration of cassava pulp that affects the production of biogas.

Keywords

biogas; Cassava pulp; hydrolysis; methane; total solids
Rhamnolipids accelerate methane hydrates formation in a fixed bed silica gel system

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Abstract
Gas hydrates or Clathrate hydrates are non-stoichiometric crystalline molecular complex consisting of water and small gas molecules. Gas hydrates has demonstrated its potential in gas storage, transportation, separations and as an alternative future energy resource. However, extensive application of gas hydrates in afore mentioned areas are restricted due slow formation rate. The present study looks into the possibility of using rhamnolipids in enhancing methane hydrate formation rate in fixed bed porous medium comprising of C type silica gel. Rhamnolipid was produced by rhizospheric bacteria Pseudomonas aeruginosa strain A11. Purified rhamnolipid reduced the surface tension of water to 36 mN/m. Detailed characterization of purified biosurfactant by analytical techniques indicated rhamnolipid to be a glycolipid type biosurfactant. Strain A11 produced rhamnolipids as a mixture of monorhamnolipids and dirhamnolipids. The most abundant dirhamnolipid and monorhamnolipid were RhaRhaC10C10 and RhaC10C10, respectively. Addition of rhamnolipids to methane hydrate formation system increased the number of moles of methane consumed during hydrate formation. Induction time was reduced when C type silica gel was saturated with rhamnolipids in comparison to quiescent water system and silica gel system lacking rhamnolipids. Saturating C type silica gel with rhamnolipids solution also increased the hydrate conversion significantly. Thus, suggesting that rhamnolipids produced from P. aeruginosa strain A11 can be used as a green promoter for formation of methane hydrate in fixed bed system of silica gel.

Keywords
biosurfactant; glycolipids; induction time; Rhamnolipids; methane hydrates

Acknowledgments
The support provided by sending Mr. Amit Arora on study leave from Shaheed Bhagat Singh State Technical Campus, Ferozepur to Indian Institute of Technology, Roorkee is highly acknowledged. The support from institute namely Indian Institute of Technology, Uttarakhand, Roorkee, National Chemical Laboratory (CSIR lab), Maharashtra, Pune, India, Institute of Microbial Technology (CSIR Lab), UT, Chandigarh, India, Keshav Dev Malviya Institute of Petroleum Exploration, Oil and Natural Gas Corporation (ONGC), Uttrakhand, Dehradun, India and Indian School of Mines, Jharkhand, Dhanbad, India, Indian Institute of Technology, Roorkee, India and Gas Hydrate Research & Technology Centre,
Oil and Natural Gas Corporation Ltd (ONGC) ONGC Complex Phase-II, Panvel, Navi Mumbai, India and Indian Institute of Technology, Chennai is highly acknowledged.
Introduction of a separate collection scheme of food waste in Wrocław: a case study

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Abstract

About one third of the food produced is wasted. However, prior to the consumption stage also losses occur up in the logistic chain. Including the losses in agriculture, storage, transport and retail up to half of the potential is wasted. The prevention of food waste is getting more and more in the focus of policy makers. However, not all food waste is avoidable. In the Interreg-Central Europe project STREFOWA (Strategies to Reduce and Manage Food Waste in Central Europe), coordinated by the University of Natural Resources and Life Sciences (BOKU) in Vienna, sixteen measures for the prevention, collection and treatment of food waste are introduced. The activities in Wrocław are concerned with the separate collection of food waste that could not be prevented from consumers.

In Wrocław, like in most other Polish municipalities, from 2013 the municipality has taken control over the municipal waste management system. Paper, glass, plastic and metals are collected separately. Concerning biodegradables, only garden waste is collected in low-rise areas, in bags. In Poland the latest by the end of the year 2021 all municipalities are obliged to introduce separate collection schemes for biowaste. In the recent ordinance on methods of selective collection of specific waste streams (from 29.12.2016) it is stated that biodegradable waste, specifically biowaste, should be collected separately in bins. Municipalities should imply this when starting new collection contracts, the latest by July 1st, 2021. Wrocław recently tendered long term collection contracts, so a city-wide separate collection of biowaste will likely be introduced by 2021 only.

In this paper the introduction of a pilot for the additional collection of food waste in Wrocław is presented. The pilot is implemented at 1000 inhabitants in low-rise and 1000 inhabitants in high-rise areas. The concerned households receive means for temporary storage of the kitchen waste both inside and outside the homes.

To monitor the effects of the introduced pilot, the amounts collected in the high- and low-rise areas continuously measured. Apart from that, the composition of residual waste and separately collected biowaste in the concerned areas are determined four times per year.

Keywords
food waste; waste collection; waste management; biowaste
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Biodiesel by means transesterification of sunflower oil with methanol, using lipases immobilized as catalyst

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Abstract

The synthesis of biodiesel by transesterification of sunflower oil with methanol, using immobilized lipases as catalysts, has been carried out. These lipases are very selective and, for its heterogeneous nature, can be separate of the reaction midway and reused at a later time. This work, in consonance with the use of renewable sources of energy, supposes the utilization of new reusable catalysts and that, contrary to the catalysts basic, do not create problems to the environment. The process has been executed operand in continuum in relation to methanol and in discontinuous in relation to the sunflower oil. This methodology has been compared to other ones published previously and a kinetic model, that predicts the variation of the conversion with time, has been established. Temperature (30-50 °C), methanol flow (0.005 to 0.04 mL/min.100g of oil), lipase type (Lipozyme 62350, Lipozyme TL IM, Novozym 435 and Pseudomonas cepacia Sol Gel AK) and lipase concentration (1.25 % to 10 % in weight in relation to oil) were the variables of operation studied. The majority ester are linoleate (56 %), oleate (30%), palmitate (6 %), and stearate (4 %). The final biodiesel was characterized determining density, viscosity, flash and combustion points, cold filter plugging point (CFPP)), saponification and iodine values, Conradson residue, characteristics of distillation, cetane value, higher heating value (HHV) and acidity index. These parameters, except the CFPP, presented similar values to the motorization diesel.

For methanol small flows, the rate of the process is directly proportional to methanol concentration, but from a given concentration the rate is independent of this variable. Elevated flows cause the deactivation of the catalyst, decreasing the final conversion. Kinetically, the reaction requires times of 30 to 35 h for conversions of 95-98 % in the best conditions of reaction. Novozyme 435, Lipozyme TL IM and Lipozyme 62350 cause similar maximum reaction rates, but the Novozyme 435 presents bigger resistance to the deactivation for excess of methanol. On the other hand, Pseudomonas cepacia only gets conversions from the 1 %. The concentration of catalyst, to a limit of the 2.5 %, act positively upon the reaction rate and the maximum conversion. The optimum temperature was of 40 °C and the initial reaction rate complies with Arrhenius' law to a level of 50 °C. By means of application of the differential and integral data analysis methods, the kinetic parameters of the models of Michaelis Menten, competitive inhibition and Ping-Pong bi-bi with inhibition of substratum, have been determined. Michaelis Menten's general model does not describe the behavior of the reaction due to the deactivation of the catalyst. The other two models, that take into account the presence of two substratums, are more adequate.

Keywords

biodiesel; transesterification; sunflower oil; immobilized lipases; kinetic study
RESRB2017.0048

Utilization of solar concentrated collector for preheating drying agent for coal/biomass dryer

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Abstract
A linear solar concentrating collector has been researched experimentally. It plays the role of high-temperature thermal oil heater and is a major component of the coal/biomass drying plant. In experiments hot oil was heated to 250 °C, sent from the absorber to the heat exchanger where it was cooled by air. The agent was then used as a drying agent in a dryer with a high moisture content materials such as brown coal, biomass etc. The volumetric flow of air of about 90 m³/h was tested and the minimum temperature ensuring the economic viability of the whole system was 60 °C.

Fig.1. Installation diagram with the concentrated collector.

The investigated pipe absorber had a length of 12 m and diameter of 0.07 m. The collector concentration was 11.91. Overall, the experiments allowed us to determine the operating characteristics of the solar oil heater under Poland’s weather conditions.

Keywords
solar dryer; coal/biomass drying; linear solar concentrating collector; biomass valorisation

Acknowledgments
This work was financially supported within the framework of the project ‘Multi-fuel energy generation for Sustainable and Efficient use of Coal (SECoal)’, KIC InnoEnergy.
Harvesting of apple (Malus Mill.) pruning in Germany using a new pruning round baler prototype

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Abstract
Apple tree branches derived from health pruning form an important source of biomass, which should be used for energy generation purposes. The global surface area occupied by apple orchards is ca. 5.0 million hectares. Assuming that one hectare of apple orchard provides on average 3.5 tonnes of pruned biomass during preservation pruning then the potential of this valuable wooden residue would yield over 17.5 million tonnes per year. In Europe, there are potentially large amounts of unused branches forming residues of health pruning in orchards, vineyards or fruit bush plantations. The pruning may be successfully used for energy purposes as renewable fuel. One of the main barriers which make it difficult is the lack of complete technologies for mechanization of harvesting these products. In order to be usable in a wide range of different types of orchards and vineyards, in the frame of the EuroPruning project a new baler adaptable to different site conditions was designed and constructed. The article presents the results of a new PRB 1.75 machine performance testing, conducted during branch harvesting in two apple (Malus Mill.) orchards located in north-eastern Germany. The tests were aimed to determine the potential amount of yield of branches per orchard area unit, to assess the machine efficiency in two different operation configurations, and to identify the most important variables affecting the changes in these parameters. In both cases, the average yield of pruned branches was similar. For Orchard 1 it was 3.31 t∙ha⁻¹, and for Orchard 2 it was 2.89 t∙ha⁻¹. The productivity obtained during testing was 3.10 t∙h⁻¹ for operation without windrowers, and 3.21 t∙h⁻¹ for operation with windrowers. The average area efficiency, obtained in the tests, was 1 ha∙hour⁻¹, and the average value of losses measured in investigated orchard was 22% with the machine working with activated windrowers and 37% without the use of windrowers.

Keywords
pruning; orchard; biomass bale; harvesting losses; agricultural residues

Acknowledgments
The study was performed as part of the EuroPruning project. EuroPruning is co-financed by the Seventh European Commission’s Framework Programme for Research, Innovation and Knowledge-Based Bio-Economy (KBBE). The tasks of PIMR are partially financed from the resources for science in 2013-2016, granted for a co-financed international project.
Numerical modelling of anaerobic digestion of different biomasses in a batch reactor

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Abstract
Anaerobic treatments of biomasses are among the oldest biological process technology used by mankind. The anaerobic digestion technology has important environment benefits; also it can become a source of income for farmers. The economic efficiency in the anaerobic digestion depends on the investment costs, operation costs of the biogas plant and the optimum methane production [1]. The main aim in this study is to evaluate the biogas production and quality from different biomasses (microalgae, sorghum, pig manure and corn stubble) in a digestion process carried out in a batch reactor. Moreover, a generic numerical model on the anaerobic digestion process has also been developed, which could be very useful for implementing applications for full-scale plant design, operation, and optimization.

The substrates were characterized by different techniques. Anaerobic digestion was carried out as batch tests in mesophilic conditions (about 38°C) for a period of 30 days in a digester of 5 L. The inoculum to substrate ratio was in the range of 0.4 to 1.1. Mechanical agitation in the biodigesters was controlled by an independent regulator allowing optimal contact between substrates. Gas composition and total gas volume produced were monitored during the experiments with a gases analyser Awite System of Analysis Process serie 9. Gas counters (Ritter model MGC-1 V3.2 PMMA). The biogas was stored in tedlar bags and analysed by five different sensors to hydrogensulfide, oxygen, methane, carbon dioxide and hydrogen.

The model considers 19 biological processes, involving disintegration of biomass composite, enzymatic hydrolysis, and digestion of soluble materials mediated by organisms. Coupled with these biological processes, there are several acid-base equilibria which are not biologically mediated. Moreover, the model takes into account the liquid-gas transfer, considering the diffusion and natural convection of the gaseous species.

The CH₄ production of the different biomasses assayed was 86-293 L/kg of VS with a CH₄ percentage of 49-60%. The model allows us to obtain a true 3-dimensional picture of the processes taking place, such as the concentrations evolution of all species in any point of the whole reactor (liquid and head-space phases), allowing us to evaluate the CH₄ formation from the different biomass fraction or to predict the gas composition in the biogas produced.


Keywords
biomasses; anaerobic digestion; biogas; methane yield; numerical analysis

Acknowledgments
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**Electrical and magnetic properties of carbon fibers coated with Fe-Ni alloy**

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**Abstract**

Common EMI absorbing materials such as metals have been widely investigated and are normally used for EMI shielding materials. However, it has some disadvantages, such as high density, uneconomic processing, and poor environmental adaptability. Due to high electrical conductivity, light weight and excellent mechanical properties, carbon fibers are adequate substance for microwave shielding materials. However, to meet the application needs in the field of electromagnetic shielding, the magnetic and electrical performances of carbon fibers should be improved. The Fe-Ni electroplating method was used to improve the electrical and magnetic properties of carbon fibers. For finding the appropriate conditions, we conducted the electroplating with different current densities. As a result of the SEM, we could observe that the number of particles is relative to the current density and irregular coating layers occur at higher current densities. Additionally, it was found that the compositions of Fe, Ni, and Oxide are relative to the current density except the carbon by the EDS. As you can see the mapping images, the shape of coated carbon fibers is similar to the mapping image in green color. Therefore, it seems that there are many iron oxide and nickel oxide onto the coating. The results of the electrical conductivity and VSM revealed that the plated carbon fibers at high current density could show the typical soft ferromagnetism. Finally, the composition elements and current density can contribute to the electrical and magnetic properties of carbon fibers.

**Keywords**

carbon fiber; Fe-Ni alloy; electroplating; magnetic properties
Role of green sustainable tribology towards renewable energy and sustainable development: present and future prospects

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Abstract

Demand for Global energy production is most likely to rise up in upcoming years, which will put an enormous amount of pressure on renewable resources of energy and the environment to meet up with rising demand for energy production. Whereas, a huge sum volume of energy can be lost to friction which leads to energy dissipation and material deterioration i.e. wear in contacting relative moving parts interfaces (sliding/rolling tribo pairs) of renewable source energy machinery. Green/Sustainable tribology is significantly important in today's world to minimise the amount energy that is lost due to the friction of mechanical components. Green tribology need to be incorporated in designing of greener and sustainable interacting mechanical (self-healing) components over entire life cycle for eco-friendly energy production processes. This paper presents an objective approach to evaluate and present the role of sustainable-green tribology towards energy production through renewable sources. It takes consideration of the environment-friendly attributes, green maintenance requirements which aim to improve product & system availability and the sustainable aspects of product design and their operation so minimising the loss of energy through tribology to a significant extent in every field. These include keeping the efficiency of machinery from deteriorating, improving wear life, reducing downtime, and new energy efficient designs of machine components utilizing eco-friendly lubricants and biomimetic approach. The aim of paper is to highlight about how energy aspects of tribology can be applied in order to reduce the dissipated energy in renewable as well non-renewable sources for sustainable development. Furthermore, the role relationship of green tribology with energy, carbon footprint, environment and sustainable development is also presented. The significance, application and challenges for energy saving in relevance to green tribology for various applications such as wind energy, blue energy, transportation, turbomachinery with energy reducing architecture are presented. The role of green/sustainable tribology will be critically important to address key issues related to energy efficiency for both renewable and non-renewable sources of energy considering the economic and societal implications of energy usage.

Keywords
renewable; green tribology; sustainable; carbon footprint; lubricant
RESRB2017.0053

The use of adhesive material to enhance cell aggregation under shear stress in high-rate anaerobic reactors

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Abstract
Shear stress created by mechanical mixing can reduce the effectiveness of high-rate anaerobic reactors. For example, the destruction of almost all flocs during continuous stirring across a wide range of mixing intensities (1-25 Hz) had been reported. The agitation-induced shear stress has a negative effect on floc formation which has been shown to inhibit biogas production. The syntrophic interaction between the working microorganisms requires close proximity of these microorganisms, often referred to as juxtapositioning. The objective of the study is to enhance cell aggregation under shear stress in high-rate anaerobic reactors using chitosan as a bioadhesive. In methods two comparative continuous stirred-tank reactors (CSTR) were used; chitosan was periodically applied to a CSTR treating raw palm oil mill effluent (POME). The other CSTR served as a control. The effect of chitosan addition on reactor performance especially methane production at high organic loading rates (OLR) was investigated. The microbial community structures in all reactors were analyzed using denaturing gradient gel electrophoresis (DGGE), and the microbial population dynamics using real-time PCR. In results it was presented that the periodic addition of chitosan can increase the efficiency of treatment of raw undiluted POME in a CSTR by removing the limiting methane production caused by the slow methanogenic rates observed in a CSTR operated without chitosan addition. The increased flocculation of anaerobic sludge was evident in the CSTR with chitosan addition. The real-time PCR data provided evidence that chitosan may specifically affect the numbers of Methanosarcinales in the sludge floc. In conclusions it is proposed that the role of chitosan is that it acts like an adhesive exopolysaccharides (EPS) which assists the methanogens to aggregate together and prevents them from being washed out from the reactor. This enhanced flocculation and the increased retention of the methanogens may help increase the close association of acetogens and methanogens that is required for the syntrophic interaction between them, especially under the mechanical mixing in the CSTR.

Keywords
biogas; biomethane, high-rate anaerobic reactors; chitosan; bioenergy
Incorporating stakeholders participation and environmental impact assessment in site selection of hybrid offshore wind and wave energy systems in Greece

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Abstract

Hybrid Offshore Wind and Wave Energy Systems (HOWiWaES) enable the combined wind and wave energy exploitation offering multiple benefits (e.g. reduction of associated costs). Therefore, they could play a key role regarding energy policy targets. Although the HOWiWaES’ environmental impacts may be considered scarce and rather insignificant, their siting selection has induced an extensive discussion about the social acceptance of this technology at global and local level.

In this paper, a methodological framework for evaluating and ranking marine areas in Greece towards the siting of HOWiWaES is presented with special focus on stakeholders-experts involvement in the decision making process as well as on the HOWiWaES’ environmental impact assessment evaluation. The appropriate sites (alternatives) considered for evaluation/ranking are derived from a previous authors’ investigation and satisfy exclusion criteria related to utilization restrictions, economic/technical constraints and social implications. The following nine evaluation criteria are considered in the present analysis, covering various environmental, economic, technical and socio-political aspects: Wind Velocity (WV), Wave Energy Potential (WEP), Water Depth (WD), Distance from Shore (DS), Connection to Local Electrical Grid (CLEG), Population Served (PS), Shipping Density (SD), Distance from Ports (DP) and Environmental Performance Value (EPV). EPV of each alternative is obtained through a weighted sum model that integrates the baseline and the potential environmental condition of various environmental components (e.g. natural environment, socio-economic environment, etc.) with the project’s construction and operational phase. Primary assessment criteria (nature and magnitude of impact) and secondary assessment criteria (permanence, reversibility and confrontability of impact) are used for evaluating each alternative’s environmental impacts. Pairwise comparison of the evaluation criteria is performed by a group of stakeholders/experts through a questionnaire survey for quantifying their relative weights with respect to the optimal HOWiWaES’ siting.

The results indicate that WV, WEP and EPV are among the most important evaluation criteria, while PS, DP and SD correspond to less influencing criteria. The proposed methodology can be easily applied to other countries worldwide for supporting socially accepted siting of HOWiWaES.

Keywords

hybrid offshore wind and wave energy systems; participatory planning; environmental impact assessment; site selection; multi-criteria analysis
Energy efficient breweries

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Abstract
This research is dedicated to energy efficiency in breweries. The approach is based on using Onion diagrams. The study evaluates energy consumption for different processing stages. Indicators found in literature are systematically evaluated and compared. Technical solutions intended to reduce energy and water consumption through different innovations are discussed. Prospects for using the employed method for other industries of the bioeconomy are examined.

Keywords
energy efficiency; brewery; bioeconomy; bioindustry; sustainability
RESRB2017.0056

4-E (Energy, Exergy, Environment and Economic) assessment of the SOLUGAS, a solar thermal gas turbine power plant in Spain

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Abstract
In recent years the contribution of renewable energies to the energy mix of many countries is increasing. Solar power plants have increased in countries with high levels of radiation, first photovoltaic and second solar thermal. Spain is one of these countries. Currently it has an installed power capacity of around 2.3 GW only for solar thermal plants. Within these, hybrid turbine gas cycle plants have also been considered, which have some added advantages such as guaranteed supply, reduced fuel consumption and CO₂ emissions.

In this work, an energetic, exergetic, environmental and economic evaluation (4-E) of the SOLUGAS power plant (Sanlúcar la Mayor, Sevilla, Spain) is performed. The plant is operating since 2013 and generates 4.6 MWₚ. The plant configuration is a modification of the commercial gas turbine Solar Turbines Mercury™ 50. The modification preheats the air mass flow on a solar receiver between the compressor and combustion chamber. The receiver is located in a tower of 67 meters of height. The radiation is collected by a heliostats field of 69 units with a reflective area of 121.3 m² each one. The solar block delivers 5 MWₚ to the power block. This contribution is more than 30% of total thermal power consumed by the plant. The analysis is performed by comparing the hybrid configuration (modified gas turbine with the solar block) versus the fossil configuration (only gas turbine). The energetic efficiency, defined as the ratio between net electricity output and fossil thermal power, is improved from 0.302 (fossil plant) to 0.4338 (hybrid plant).

We use the exergy balance of SOLUGAS plant to calculate the exergetic efficiencies along with the exergy destruction sources in all components and in the overall system to identify potentials for future improvements. This balance is plotted using the Sankey’s Diagram. Total exergy efficiency improved from 0.290 to 0.417.

From an environmental point of view, the annual fuel consumption decreases by 7% owing to the solar contribution. This means high reduction of the CO₂ emissions. The economic analysis has been carried out by calculating the Levelized Cost of Electricity (LEC) of fossil plants and the hybrid plant. The cost of CO₂ emissions has been taken into account in calculations. This 4-E analysis evaluates the techno-economic parameters of a pioneer plant in Spain to establish their techno-economic viability.

Keywords
solar thermal power plants; gas turbine; energy analysis; exergy analysis; environmental analysis; levelized cost of electricity
Waste to biodiesel refinery: a case study of Saudi Arabia

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Abstract
Biodiesel is a promising liquid fuel that is mainly derived from triglycerides and is utilized in diesel engines directly or after blending with conventional gasoline. Triglycerides comprise fatty acid methyl esters (FAME), which are generated from plant or animal based sources. Biodiesel generated from vegetable oils is expensive than petroleum-based diesel and has concerns with food vs. fuels debate. Therefore, biodiesel from renewable sources such as non-food feedstocks has attained a considerable interest in last two decades. This paper aims to examine the biodiesel generation from the non-food feedstocks available in the Kingdom of Saudi Arabia (KSA) as a source of renewable energy and value-added products along with and a solution to current waste disposal problems. In KSA, non-food feedstocks such as animal fats, waste cooking oil (WCO), agricultural wastes, sewage sludge, and microalgae are promising sources for biodiesel production. These feedstocks are relatively cheap, easily available, portable, and renewable in nature. A case study of waste to biodiesel refinery is presented for KSA under three different scenarios, including (1) KSA population in 2017, (2) KSA population and pilgrims in 2017, and (3) KSA population and pilgrims by 2030. It was assessed that around 482, 488 and 627 MW of electricity on a continuous basis could be generated every year for scenarios 1, 2 and 3 respectively if using the fat fraction of municipal solid waste in waste to biodiesel refineries in KSA. Similarly, a total net savings of US$ 272, 275.2 and 353.9 million can be achieved from scenarios 1, 2 and 3 respectively. However, there are many challenges in commercializing the waste to biodiesel refinery in KSA such as collection of feedstocks, separation of lipids, products separation, soap formation, preserving products, and adequate regulations.

Keywords
biodiesel; waste to energy; non-food feedstocks; transesterification; catalyst
Influence of homogenous and heterogeneous catalysts on biodiesel production

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Abstract
The biodiesel production has been growing over the past three decades and is expected to continue due to the depleting of fossil fuels day by day and the environmental concerns on rising CO$_2$ emissions from fossil fuel consumption. Biodiesel is one of the environment-friendly fuels that is a non-toxic and biodegradable source of energy. It is commonly produced by the transesterification of triglycerides with a low molecular weight alcohol. Around 90% of biodiesel is produced in the industrial transesterification process by using homogeneous base catalysts from vegetable oil with methanol. However, the use of virgin vegetable oil poses dilemmas, in particular, that of food versus fuel. In addition, the cheap non-food feedstocks contain high quantities (>1 wt%) of free fatty acids (FFAs), moisture (>0.5 wt%) and other impurities as shown in Figure 1. They also cause problems by forming soap (fatty acid salt) and difficulties of separation requiring aqueous quenching and neutralisation steps while transesterified through homogenous base catalysts. Homogenous acid catalysts are an appropriate choice for catalyzing these materials to form biodiesel. Nonetheless, they cannot be recovered, and demand costly fuel purification processes that are very corrosive. Therefore, heterogeneous catalysts have gained significant attention as being a promising alternative catalysts for biodiesel production from non-food feedstocks. In addition, they have proven to simplify the easy separation of product and by-products from the catalyst. This allows the catalyst reusability and reduction of waste that have a positive environmental impact. Moreover, heterogeneous base catalysts exhibit higher activity than heterogeneous acid catalysts, but they are unable to esterify large amounts of FFAs in cheap feedstocks. Therefore, solid acid catalysts have beneficial for simultaneous esterification and transesterification of cheap feedstocks containing high FFAs. These solid acid catalysts have been extensively studied as offering the biodiesel industry an alternative to homogenous catalysts in simultaneous esterification and transesterified under mild conditions. A wide range of inorganic, organic and polymeric solid acid catalysts have been recently explored to or intending to biodiesel production using cheap non-food feedstocks. However, some issues remain and still need to be resolved. Low reactivity, small pore sizes, low stabilities, long reaction times as well as high reaction temperatures are the main challenges of using solid acid catalysts in industrial applications. It is also critical to mention that calcination at a high temperature of sulfonated solid acid catalysts destroys catalyst templates, reduces their activities as well as making the process energy intensive. Surface functionalization of solid acids is an effective route to introducing functional groups on the internal or external surface for catalyst support, but it reduces the surface area and porosity of the solid acid catalyst. Therefore, designs to prevent deactivation of catalyst sites and produce efficient, cheap, durable, and stable solid acid catalysts are required to overcome current problems associated with biodiesel production.

Keywords
biodiesel; heterogeneous catalysts; homogeneous catalysts; solid acid catalysts; fuel; non-food
feedstocks
**Abstract**
This study investigates business models of renewable energy companies as a framework toward creating money and wealth. Practically, business models define company's activities such as how they benefit customers or how they generate revenues. The business model plans the ideas into economic values and show how a company makes money by specifying a position in the value chain. In this work a case study of a renewable energy company is considered and peculiarities of business models are explained.

**Keywords**
business model; innovation; renewable energy company
Numerical study of lens geometry and material effects on allowed concentration ratio of a lens-lens beam generator solar concentrator

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Abstract

Lens-Lens Beam Generator (LLBG) is a novel lens-based concentrating system in which two successive converging lenses are employed to generate a collimated concentrated solar beam. This configuration provides the flexibility in selecting the location of the solar receiver compared to conventional concentrating techniques. The LLBG optical design requires placing the rear lens in a position close to the front lens focal point under high-flux solar power. Accordingly, the rear lens geometry and material play a critical role in limiting the maximum allowable concentration ratio (CR) of the LLBG. In the present work, 3-dimensional transient thermal modelling using ANSYS Workbench software is carried out in three stages. In the first stage, a model convergence test is carried out to check the optimum number of nodes to achieve the model convergence until a maximum temperature error of 1.0E-08°C is reached. This test is applied to three different lens geometries: bi-convex, plano-convex and positive meniscus. All geometries have a diameter of 25.4 mm and focal length of 100 mm and material is assumed to be SiO₂. Hence the simulation time for each run is directly proportional to the CR assumed; all tests carried out at this stage are based on assuming a CR of 10. The incident solar flux was theoretically calculated as a function of daytime for Cranfield, UK location (52.0686°N, 0.6087°W). In the second stage, thermal behaviour of the described geometries is studied. In this study, the CR is increased and the maximum rear lens temperature is calculated in each case. Based on the assumption of lens material described earlier, the maximum working temperature of 1200°C is assumed as the stopping criterion. A comparison between maximum rear lens temperatures achieved for the different geometries versus concentration ratios applied is made. In the final stage of the study, the rear lens material effect on the maximum allowed CR is investigated. Tests are carried out by applying 13 different materials on the best geometry selected based on the second stage results. These materials include ceramics (SiC, ALON®, Spinel, Yttria), glass (SiO₂, CaF₂, BK7, Borosilicate, ULE, Sapphire, ZERODUR®) and plastics (Polycarbonate, PMMA) with transmittances ranging from 34.7 to 97.9%. According to the first stage of the study, the number of nodes for bi-convex, plano-convex and positive meniscus geometries was 22,327, 95,498 and 21,755 with maximum errors of 5.02E-10, 3.34E-09 and 3.60E-10°C, respectively. Results indicated that positive meniscus geometry withstood the highest CR compared to the other geometries. On the material side, the best results were achieved with SiC, ALON, Spinel and SiO2 which achieved maximum allowed CRs of 19,100, 16,020, 14,650 and 14,055, respectively. However, the best candidate among these materials was SiO₂ according to its transmittance over the solar spectrum to enhance the optical efficiency of the LLBG concentrator.

Keywords
solar concentration; LLBG; lenses; concentration ratio; thermal simulation

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Renewable energy: hydro, solar and wind in East Africa region

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Abstract
Worldwide, many countries are committed to joining renewable energy market but the current share of the market still low. Developing countries are increasing their amount of money to promote renewable energy deployment. The global view of investment in renewables dominated by solar and the wind where other groups are witnessing decreasing in investments. East Africa with 12 countries (Burundi, Rwanda, Ethiopia, Uganda, Kenya, Tanzania, Djibouti, Eritrea, Somalia, South Sudan, Sudan and Egypt (IEA, 2014); (Mwongereza & Boudjella, 2016) is one of five African blocs. Most of the renewable energy resources are available in the region but less developed. The renewable energy resources available range from, biomass, hydro, geothermal, solar, and the wind, of which hydro and biomass dominate in energy generation within East Africa (Othieno & Awange, 2016).

This article was drawn up with the aim of providing the status of renewable energy sources and their potential mainly focused on hydro, wind and solar in East Africa. We discussed the contribution of each group in energy production and their investment in the region. Data has been analyzed using Microsoft Excel tool, and discussion was provided based on the excel output within this study.

East Africa region is taking action every day to bring meaningful change in the energy sector to sustain her economic and force of anti-climate change initiative. There are increasing energy production by using renewables. However, we have found that renewable energy resources did not promote with the same effort. Hydropower mainly holds a large share in most region’s countries power generation. Solar followed to some extent, and the wind takes the last position. In the region, Egypt takes the first position in renewable energy deployment, followed by Ethiopia, Sudan, and Kenya respectively. A significant share of the wind in energy generation has been found in countries such as Egypt where the wind gives 610 MW and in Ethiopia with 324 MW in 2015 (IRENA, 2016). The solar technology seems popular in the most countries even if its share in power generation still at a lower level. In the region, there is an increase in investment in renewable energy and a high portion of total investment goes to power plants. Most of the forces are concentrated on Hydro regardless the potential of other groups. The investment in Hydro far exceeds investment in other energy sources within the region.

This work concluded that East Africa power production will continue to increase with a large share of Hydro, and a balanced action of investment in energy supply highly likely recommended for energy sustainability in the region. The development of renewable energy policy also is suggested in the region to promote the use of renewables in power production.

This work fits the profile of the RESRB 2017 conference as it covers themes which are on the conference agenda (Hydro, Solar, and Wind). It touches on the business side by showing the investment and opportunity available in renewable energy resources within the East Africa region.

Keywords
renewable energy; energy access; energy poverty; investment; East Africa region
Life cycle assessment on economic feedbacks in the charcoal value chain in Lusaka district, Zambia

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Abstract
Charcoal production and trade in much of southern Africa, including Zambia, is presented as a set of activities with adverse environmental impacts, largely because the socio-economic benefits of charcoal production and trade have been downplayed. This research by carrying out a life cycle assessment (LCA) with a focus on economic feedbacks (inputs and outputs) along the charcoal value chain in Zambia disputes this claim. Through this study, the highest economic costs at each stage in the charcoal value chain are assessed and the extent to which the costs incurred are suggested. This assessment shows which stage incurs the highest financial costs from the production, transportation and trade in the proximity of Lusaka District. This district, encompasses the city of Lusaka, where 32% of Zambia’s urban population resides and charcoal is a primary source of energy for 85% of urban households and the industry contributes to 500 000 people employed as charcoal producers, transporters and vendors. Despite this, charcoal has remained under-priced by more than 20-50% in relation to the economic costs thus affecting the producer who then exacerbate the negative environmental impacts. With little or current national cover, the charcoal industry has remained informal and profits have remained in the hands of a few actors in the value chain especially the transporters. In this line the study intends to provide information on the scale and economic value of the charcoal industry in Zambia, by assessing the key players along the value chain, the mechanism for revenue generation and distribution of income. The methodology involves field data collection on input and output resources at each stage of the charcoal value chain. This is through structured interviews with the key actors on how much money is put in (expenditure) and what the returns (profits/losses) are at each stage of the value chain. The results of the study shows which stage in the charcoal value chain incurs high capital costs and how it can be optimized. Simply the overall profits and losses per unit marketing margins along the value chain are the key results of this study. The implications of the findings provide material for informed decisions on investment opportunities along the charcoal value chain and making the Zambian charcoal industry economically sustainable.

Keywords
economics; value chain; charcoal; Zambia, LCA, input-output
Thermal behaviour of different biomass materials under slow pyrolysis conditions

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Abstract
The use of carbon neutral renewable sources to achieve reduction in carbon emission, soaring prices of petroleum and concerns over secured supply of energy sources are the major drivers in the search for alternative renewable energy sources. Typical and abundant biomass residues around the world, such as corn cob, vine rod and sunflower have potential to produce energy when subjected to pyrolysis conversion through biogas, bio-oils and bio-char products of pyrolysis. The subject of investigation of this work was to determine the thermal behaviour of these three biomass agricultural materials under slow pyrolysis conditions to quantify their energy content. In this work, a variety of technological tools were employed to characterise the pyrolysis of the three samples. The thermo-gravimetric analyser and proximate analyses were used on the raw samples to monitor the mass change and characterise the samples. The organic compounds contained in the pyrolysis oils at 500°C were investigated using gas chromatography-mass spectrometry (GC-MS). The solid char products of pyrolysis at 500°C and the raw samples were analysed using Fourier transform-infrared (FT-IR) spectroscopy.

The results indicate change in functional groups between raw and solid char products, which refers to the loss of organics after pyrolysis at 500°C. The composition in the bio-oil was compared of the selected biomass materials. Through proximate analysis, the calorific value was determined. The obtained data will provide important reference information for energy and fuel generation from pyrolysis of the analysed biomass.

Keywords
slow pyrolysis; corn cob; vine rod; sunflower; energy use
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Sustainable ethanol production from waste biomass in semi-arid and tropical regions

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Abstract
Semi-arid and tropical regions worldwide face the challenge of providing energy security to its population without impacting food security and the environment. Bio-based fuels can make a significant contribution to this challenge, especially if they are produced from agricultural and urban wastes. The use of these sources can generate revenues and development for the rural communities, as well as reduce their energy imports. In this article, the Semi-arid Region of Brazil is used to contextualize this discussion. This region has marginal soils and is subjected to recurrent droughts. There is a good established supply chain of biofuels, but it is based on soy and sugarcane that are produced in more fertile regions of the country. The Semi-arid region of Brazil has a relevant potential for the production of ethanol using local agricultural wastes. This research assesses that potential, by studying a selected set of local lignocellulosic wastes. It was conducted an extent literature and data review of agroforestry wastes available in the region, their composition and cellulose content, and their ethanol yields according to the state-of-the-art. The development of a waste-to-ethanol industry from the studied set of agroforestry wastes has the potential of adding up 0.9 billion L of ethanol each year and reduce the imports of this fuel by 29% in the region. The implications for the regional flex-fuel market were also addressed. It was found that diversifying the sources of ethanol would reduce the seasonal variation of its supply in the region, leading to two main consequences: its price would have less seasonal oscillations and the current stock capacity could be decreased by 70%. Lignocellulosic ethanol still needs to achieve competitive production costs and overcome uncertainties regarding technology and logistics, but in the long-term the influx of significant volumes of 2G ethanol in the region would make this biofuel to gain competitiveness towards gasoline.

Keywords
agro-waste; waste biomass; agroforestry residues; lignocellulosic ethanol; bioethanol; semi-arid regions
Woody biomass potential and mitigation of territorial disparities in center development region of Romania

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Abstract
The utilization of biomass energy has considerable effects on the local society and local economy. The study contains the quantification of woody biomass potential on the lowermost level of administrative units (level NUTs 5) in the case of Center Development Region of Romania. The study performs evaluation of the woody biomass potential by using an integrated methodology. The biomass potential calculations show that villages with the largest local potential are, at the same time, underdeveloped rural regions. We compare the local biomass potential index (BPI) with the Local Human Development Index (LHDI) to demonstrate where is the biggest opportunity and where there are opportunities for the biomass based rural development. The study briefly presents where are already implemented woodchips/wood waste based applications. The results are presented using Geographic Information System (ArcGIS). In conclusion, local development proposals are formulated.

Keywords
woody biomass; biomass potential index; rural development
The recycling of municipal solid waste and circular economies: a case study of Saudi Arabia

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Abstract

Today, the world is facing the challenges of the security of food, water and energy, economic growth and jobs and increased competitiveness and innovation. The nations have to change the traditional linear economy model having the pattern of taking, making, consuming and throwing away with a circular economy model that inherit the principles of sharing, leasing, reusing, repairing, refurbishing and recycling. Currently, the poor municipal solid waste management (MSW) in developing countries is resulting in several environments and public health issues such as the contamination of soil and groundwater, greenhouse gasses (GHG) emissions, disease spreading vectors, flies and rodents, fire outbreaks, odors and air and waterborne pollutants. Although, many developing countries have ambitious plans to improve MSW standards like developed nations, but due to limited allocated budgets to MSW, poor enforcement of the waste handling regulations, lacking necessary infrastructure and machinery and weak public participation in the policy and decision-making process are unable to achieve their objectives. Recently, in the Kingdom of Saudi Arabia (KSA), a new policy of Vision 2030 is launched to safeguard the local environment through increased MSW recycling, pollution prevention schemes and developing renewable energy sources. The informal sector manages the activities of MSW recycling in the country. It is estimated that due to the absence of MSW recycling in the country, a loss of around US $10.76 billion occurs every year. In addition, it is estimated that during 2015, around 7.6 million tons of recyclable materials were generated, including 3.2 million ton of waste paper in the country, which will increase up to 11.9 and 5 million ton respectively by 2030. It is estimated that only by waste paper recycling in KSA, a net value of US $1.4 billion can be achieved along with around 16 thousand new jobs, savings of around 9.6 million crude barrels and 4.5 million ton of CO2 from GHG emissions by 2030. However, the challenges like adequate financing, major economic enablers, skills, consumer response and new business models have to address in order to get the expected outcomes of MSW recycling in the developing countries.

Keywords

waste recycling; municipal solid waste (MSW); Hajj and Umrah; Medina City; greenhouse gas (GHG); Vision 2030
RESRB2017.0067

Business model innovation: general purpose technologies and their implications - a case study of an oil company

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Abstract
The importance of business model as a framework toward creating money and wealth. Practically, business model suggests a company’s activities such as benefit customers and expected the company’s benefit citizens and achievement. Moreover, Business model describes how companies create added value for the product or service works and performance. Furthermore, the business model plans the ideas into economic values and show how a company makes money by specifying a position in the value chain, to the preparation of its business model. Finally, the research output of this qualitative activity is to propose business model for Sepahan Oil Company as case study.

Keywords
business model; innovation
RESRB2017.0068

Review on some experimental work on rheological behaviour of oxide nanofluids and their hybrids

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Abstract
Engineered suspensions of nanoparticles in common liquids, known as “nanofluids,” have generated substantial interest for their potential to enhance the heat transfer rate in different systems, while reducing, or possibly eliminating, the issues of erosion, sedimentation and clogging that plagued earlier solid-liquid mixtures with larger particles (i.e. colloids). Over the last years a large quantity of research (both experimental and numerical) was dedicated to this area and starting about 2-3 years ago, some researchers proposed hybrid nanofluids as a more convenient alternative in order to balance the thermophysical properties and to increase the thermal conductivity while decreasing viscosity. Hybrid nanofluids are obtained basically by three methods: mixing two nanofluids, suspending at least two kind of nanoparticles in the same fluid or by adding nanocomposites to a regular heat transfer fluid.

This article fits in the new materials area and presents some experimental studies on rheological behaviour of some nanofluids based on water and their hybrids. The nanoparticles considered for this study are alumina and SiO\textsubscript{2}.

The aim of this work is to study the influence of adding nanoparticles on the viscosity of a basic heat transfer fluid (i.e. water) and to recommend a correlation that can be used to estimate the viscosity of nanofluids based on Pr and volume fraction.

The selected methodology allowed us to measure the nanofluids viscosity and to compare it with the viscosity of the base fluid. The equipment used is an Anton Paar, Physica MCR 501, rheometer with high capabilities and very good results accuracy.

The obtained results, based on experimental work, reveal a non-newtonian behaviour for small shear rates which changes to newtonian with increasing the shear rate. There is a large debate in the literature on this issue and, to be able to draw some conclusions, the final real life applications of nanofluids have to be considered. The rheological properties of the base fluid and nanofluids were estimated using the shear stress versus the shear rate curves.

In conclusion, this research gives a novel approach and makes a difference to the state-of-the-art in the area of nanofluids by trying to shed some light on the rheological behaviour of simple and hybrid nanofluids and to offer a comprehensive correlation for estimating the nanofluids viscosity.

Keywords
nanofluids; viscosity; experimental; rheological behavior
Feasibility study of pilot scale gasification systems for rice husk power generation in Java Island, Indonesia

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Abstract
Indonesia is the third-largest rice producer countries in the world with the total production capacity of around 70 million tons per year. Rice husk is the main residue from rice milling and is about 20% of the paddy grain weight. Typical utilization of rice husk includes fertilizer, animal feed and as cooking or heating fuel. Rice husk fuel has a lower heating value of about 14 MJ per kg that is about half of coal heating value. Therefore, there has been significant interest in recent years in generating power from the rice husk instead of heat using the gasification technology. The process of gasification converts the rice husk into a synthetic gas that can be used for electricity production. This paper aims to examine the potential of rice husk in electricity generation for on-grid applications using gasification technology. The study was carried out by collecting the rice husk from two provinces of Indonesia such as West and East Java. The data was collected in the paddy plantation area, paddy production, rice milling industry and electrification ratios. It was decided based on the potential analysis of collected data to develop the rice husk gasifier power plants in Indramayu District of West Java and Lamongan District of East Java. The basic engineering design (BED) and detailed engineering design (DED) for these plants were carried out after selecting the plant locations. The plant was designed for 100 kWe electricity capacity using a fixed bed reactor equipped with a gas cleaning system. The design was made as simple as possible so that a local manufacturer can fabricate the reactor. In addition, the economic analysis has been carried out using the primary methods of NPV (Net Present Value), IRR (Internal Rate of Return) and PBP (Pay Back Period) assessment. The results showed that the economic viability of the proposed system is always acceptable with positive PBP and NPV values.

Keywords
rice husk; biomass; gasification; power plant; economic analysis; waste to energy

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Feedback from conference participants

“The virtual presentation is a great opportunity for participants who are lacking economic resources. The proceedings are OK and highlight my research. My full paper will be 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.”

Javier Rodríguez Martin, Department of Energy Engineering, ETSI Industriales, Universidad Politécnica de Madrid, Madrid, Spain

“The renewables are the need of the hour. This conference is a platform for leading international experts on matters related to technicality and business of renewable energy sources. It is indeed a wonderfully organized and worthwhile event at which a multitude of widely diverse and emerging dimensions of renewables are deliberated. Since it was my first opportunity to see Poland, I visited many new places and experienced the local culture. The hospitality extended to me during my stay at Wrocław was excellent. I would like to be an active part of future editions of RESRB conferences.”

Bhaskar Singh, Central University of Jharkhand, Ranchi-Jharkhand, India
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