Book of Abstracts (DRAFT)

4th Renewable Energy Sources - Research and Business conference

July 8 - 9, 2019, Wrocław, Poland

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Scope

The **Renewable Energy Sources - Research and Business (RESRB)** conference is designed as a platform for reporting, discussing, improving and disseminating recent developments in renewable energy science, technology, business and policy. 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. The conference through its unique research & business model will facilitate synergies between academia and commercial sectors. Delegates from enterprises seeking innovations and expanding to new markets may benefit from sponsoring, exhibiting and networking thus improving their business environment. RESRB is particularly focused on countries applying green growth policies and plays the role in informing policymaking processes. The participation mode can be either in-person or virtual. Publication will be on Book of Abstracts, Proceedings, journals, edited books and books.

Themes

The **4th RESRB 2019** conference focuses on five key renewable energy areas: (1) bioenergy, (2) wind, (3) solar, (4) hydro and their (5) business development. The special theme for the 4th RESRB 2019 is:

- Innovation Driven Renewable Energy Development

Other main themes are:

- Renewable Energy Harvesting Technologies
- Renewable Energy Economics, Business, Policy and Management
- Innovation in Renewable Energy Projects

Additional RESRB themes include:

- Solar photovoltaics
- Wind
- Hydro
- Solar thermal
- Concentrated solar power
- Geothermal energy
- Wave, tide and other marine energies
- Biofuels
- Heat pumps
- 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
- Power system, power electronics, smart grid
- Technologies involving renewable energy: e.g. food drying, irrigation, 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 4th RESRB 2019 conference aims at disseminating the recent progress in most important areas of renewable energy research, business and policy. This fourth edition brings together participants delivering 46 abstracts published on Book of Abstracts.

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. In recent years several RE technologies became competitive in energy markets and can be implement without or with insignificant subsidies. This created market pull that will accelerate energy transition.

In recent years major investments in RESs took place in countries where capital was available and not in countries which had potential towards RESs. However, investments in developing countries now also accelerate emphasising that transition to RESs has a truly global character.

The characteristic feature of RESs that contrasts with fossil fuels is that the RES cannot be easily economically controlled, because it is in a distributed way available in nature. This fact immensely affects the economics of RESs. 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.

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.

Given the rising share of RESs, mostly solar and wind, and the ambition of the EU to reach 100% of RES in energy consumption by 2050, an increasing mismatch appears between supply and demand. One of the keys to unlock the massive adoption of RESs is energy storage. It prevents curtailment of overcapacity and compensates the lack of production due to intermittent character of RESs. Although many studies focus on energy storage, the paradigm needs to be shifted towards a versatile and robust energy generation and storage. Overall, we need smart energy systems that enable to maximise the benfits of RESs and this conference is a platform where technology, business and policy perspectives can meet and interact facilitating the creation of optimal energy systems.

Two RESRB 2019 presentations were highlighted as keynote lectures. The keynote lectures addressed some of the essential research, business and policy aspects of RESs.

In addition, many interesting oral lectures and short communications were presented and well received by the RESRB audience.

The ISC and SAB meeting informed on conference publication models such as internal reviews, journals, edited books and books as well as discussed possible improvements in the organisation of future editions of RESRB conferences such as enabling access to slides and video materials via the conference website.

Panel discussion was dedicated to commercialisation of innovative renewable energy technologies. Discussions related to various important commercialisation issues. For instance, technology demonstration in operational environment (large-scale, close to market conditions, etc.) was stressed as one of major issues capable of attracting investors. It was suggested that a large private investor always selects only best options available to him while another investor may at the same time select different options which means that for successful commercialisation investment options need to be considered by many potential investors. Effectiveness of patenting as a route to commercialisation was addressed. Also commercialisation by means of capital investment, organic growth and seeding grants were compared. Finally, benefits arising from advertising at thematic events and conferences facilitating networking and closer interactions especially between inventors and investors were emphasised.

Award Committee decided to announce the following Awards at RESRB 2019:

(1) Best conference oral lecture - A.A.

(2) Best conference lecture by student - B.B.

The winners are invited as keynote lecturers to one of future editions of RESRB conference.

W. Budzianowski

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Danijela Urbancl, Marko Agrež, Jurij Krope, Darko Goričanec*
RESRB2019.0038 - Adoption factors of environmentally sustainable energy technologies in different countries: focused on residential heating systems
Diana Londoño-Pulgarin, Luis Gabriel Agudelo-Viana, Francisco Muñoz-Leiva, Esmeralda Crespo*
RESRB2019.0039 - Assessing social acceptance of wind energy through policy comparative analysis
Cecilia Nardi, Marina Penna, Laura Gaetana Giuffrida, Elena De Luca*
RESRB2019.0040 - Symmetric electrodes for supercapacitor applications based on Zn:Mn oxide spray deposited thin films
J.J. Peinado, M.C. López-Escalante, A. Brito, E. Navarrete-Astorga, D. Solis, L. Dietmar, J.R. Ramos-Barrado, F. Martín*
RESRB2019.0041 - Efficiency modelling of complex planetary mechanical transmissions used in renewable energy systems
Mircea Neagoe, Radu Saulescu, Codruta Jaliu, Olimpiu Munteanu*
RESRB2019.0042 - Experimental research and simulation of computer processes of heat exchange in a heat exchanger working on the basis of the principle of heat pipes for the purpose of heat transfer from the ground
Łukasz Adrian, Szymon Szufa, Piotr Piersa, Krystian Kurowski*
RESRB2019.0043 - Smart cane with solar energy supply for the welfare of people with visual disabilities
*Daniel Icaza, Luz Cardenas**
RESRB2019.0044 - Energetic, exergetic, environmental and economic comparison between serial and parallel schemes of hybrid solar gas turbines
Sofía Rodríguez Pita, Javier Rodríguez Martin, Celina González Fernández, Susana Sánchez-Orgaz, Ignacio López Paniagua*
RESRB2019.0045 - A new form of decentralized energy: lessons from the WiseGRID project
*Rafael Leal-Arcas**
RESRB2019.0046 - Low carbon Arctic smart community: the ultimate case study of an Arctic renewable energy perspective
*Gisele M. Arruda**

Programme

Monday 8 July 2019	
08.45-09.00	Registration (Hall)
09.00-09.05	Opening session (Room A)
09.05-09.30	Keynote lecture session 1 (Room A) Business model valuation for emerging grid-scale storage technologies *Kourosh Malek*, Jatin Nathwani* *speaking author at University of Waterloo, Waterloo, Canada
09.30-10.00	Coffee break (Hall)
10.00-12.00	Oral lecture session 1 - Solar energy (Room A) Photovoltaics design and synergy with landscape: multifunctional land use nexus between renewable energy production and water supply *Teodoro Semeraro*, Alessandro Pomes, Amilcare Barca, Cecilia Del Giudice, Marcello Lenucci, Roberta Aretano, Alessandra Scognamiglio* Time-dependent model of solar thermoelectric generators for enhancing conversion efficiency *An-Chi Wei*, Mu-Wen Lin, Jyh-Rou Sze* To study the effect of air gap on delivery temperature of a novel batch solar water heater with CPC reflector using multi linear regression tool in (SPSS) *Jaji Varghese*, Samsher, Manjunath K, Awari GK* Infrastructure assessment through solar energy harvesting *K. Wayne Lee*, David Schumacher, Austin DeCotis, Sze Yang* PV-integrated solar-chimney assisted low-cost self-sustained circular greenhouse for protected cultivation and floriculture *Sudip Ghosh*, Debjit Misra* Measuring and comparing the transmittance of soiled PV glass surfaces in terms of global solar radiation *Karim Menoufi**
12.00-12.30	Oral lecture session 2 - Business development I (Room A)
	Determination of the optimal water intake points for a salinity gradient energy plant on a stratified river mouth *Jacobo M. Salamanca*, Oscar Álvarez Silva, Aldemar Higgins, Fernando Tadeo* Smart Combinatorial Technology to shift the materials R&D paradigm from time/energy consuming labor to intelligent game and business for fun *H. Koinuma*, T. Matsuura, N. Matsuki, R. Takahashi, M. Lippmaa*
12.30-13.15	Lunch break (Restaurant)
13.15-14.30	Oral lecture session 3 - Biogas (Room A) Hydrogen production by methane steam reforming over Co-Ni mixed oxides prepared via layered double hydroxides precursors *Sara Hany*, Muriel Chaghouri, Cédric Gennequin, Antoine Aboukaïs, Edmond Abi Aad* Zero Waste Egg Production: modeling of valorization of poultry manure *Andrzej Białowiec, Ewa Syguła, Piotr Manczarski, Jacek A. Koziel* Effect of organic loading rate on the anaerobic digestion of exhausted sugar beet pulp and its co-digestion with animal manures: enhancement of methane and volatile fatty acids productions *Kaoutar Aboudi*, Xiomara Gómez-Quiroga, Carlos José Álvarez-Gallego, Luis Isidoro Romero-García*

	Energetic and economic comparison of agricultural biogas plants fed with silage and food waste *Jacek Dach*, Wojciech Czekała, Patrycja Pochwatka, Isaias Emilio Paulino do Carmo, Alina Kowalczyk-Juśko, Jakub Pulka* Real biogas analysis and energetic valorisation by catalytic reforming *Muriel Chaghouri*, Sara Hany, Cédric Gennequin*, Fabrice Cazier, Catherine Rafin, Etienne Veignie, Edmond Abi Aad* The impact of biowaste pasteurization on the methane yield in the fermentation process *Jakub Pulka*, Jakub Mazurkiewicz*, Wojciech Czekała, Patrycja Pochwatka, Marta Cieślik, Filip Tarkowski, Jacek Dach** Kinetics of biomethane formation during multi-co-fermentation of organic waste from food industry *Sylwia Stegenta, Paula Żak, Hubert Prask, Małgorzata Fugol, Agnieszka Medyńska-Juraszek, Bogusław Dulian, Andrzej Białowiec* The possibility of gaining profit on a rational management of digestate *Wojciech Czekała*, Patrycja Pochwatka, Jacek Dach, Jakub Pulka, Kamil Kozłowski, Filip Tarkowski* Construction and evaluation of a dry anaerobic digestion reactor for the degradation of solid waste from the textile industry by the use of fungal keratinolytic strains *C. Munive-Talavera, J. Barreda-Del-Carpio, M. Salamanca-Valdivia, L. Cárdenas-Herrera*, R. Garate-Manrique, G. Moscoso-Apaza, J. Villanueva-Salas* Production of biogas in a dry anaerobic digestion reactor of residues generated in the processing of sheep and alpaca wool *M. Salamanca-Valdivia, L. Cárdenas-Herrera*, J. Barreda-Del-Carpio, C. Munive-Talavera, R. Garate-Manrique, G. Moscoso-Apaza, J. Villanueva-Salas* Modelling biogas production from a closed solid waste landfill *Hani Abu Qdais*, Fayez Abdulla, Rasha Qdeisat* Comparison of the spatial distribution of agricultural biogas plants in relation to generated power *Patrycja Pochwatka*, Jakub Pulka, Wojciech Czekała, Jacek Dach*
14.30-14.45	Coffee break (Hall)
14.45-15.45	Short communication session 1 (Room A) Novel Ni/Ce_xKIT-6, Ru/Ce_xKIT-6 and Ni-Ru/Ce_xKIT-6 catalysts for the dry reforming of methane: a comparative study *Rita Mahfouz*, Samer Aouad, Cedric Gennequin, Jane Estephane, Antoine Aboukaïs1, Edmond Abi-Aad* An expert-based technology evaluation for assessing the potential contribution of energy technologies to Italy's decarbonisation path *Elena De Luca*, Alessandro Zini, Oscar Amerighi, Gaetano Coletta, Maria Grazia Oteri, Laura Gaetana Giuffrida*
15.45-16.00	ISC and SAB Meeting (Room A)
Tuesday 9 July 2019	
08.55-09.00	Registration (Hall)
09.00-09.30	Keynote lecture session 2 (Room A) Opportunities and challenges of renewable energy utilization for power generation *Hashem Nehrir** *speaking author at Montana State University, Bozeman, USA
09.30-10.00	Coffee break (Hall)
10.00-12.30	Oral lecture session 4 - Business development II (Room A)

	Novel encapsulant architectures on the road to photovoltaic module power output increase *M.C. López-Escalante*, J.R. Ramos-Barrado, F. Martín* Model selection uncertainty and industrial energy consumption *Djula Borozan*, Luka Borozan* Impact of renewable energy on the environmental efficiency of electric vehicles *Rosen Ivanov*, Ivan Evtimov, Gergana Staneva, Georgi Kadikyanov* Case study of rural residential housing energy-efficiency gains: switching from coal to renewable energy *Aleksandra Siudek*, Anna M. Klepacka, Wojciech J. Florkowski* Modelling of automatic generation control for multi-area integrated power system equipment including renewable energy systems *M. Furkan Yılmaz, Haluk Gözde, Mehmet Karakaya, M.Cengiz Taplamacıoğlu** Alternative designs on liquid-flow window technology *Tin-Tai Chow*, Wenjie Liu* Evaluation of the influence of three microbial strains in the composition of the biol obtained from the treatment of residues of the textile industry *N. Villavicencio-Muñoz, J. Barreda-Del-Carpio, L. Cárdenas-Herrera*, R. Garate-Manrique, G. Moscoso-Apaza, J. Villanueva-Salas* Renewable energy resources for better economics and sustainable living in rural and desert areas *Karl Gatterer, Salah Arafa**
12.30-13.15	Lunch break (Restaurant)
13.15-13.45	Oral lecture session 5 - Bioenergy (Room A) New empirical production models for poplar plantations on farmland - a toolbox for improved management and planning operations *Birger Hjelm*, Tord Johansson* Increased energy efficiency and renewable energy use for high temperature heating *Danijela Urbancl*, Jurij Krope, Darko Goričanec* Pentanol as biofuels in compression ignition engines *Soo-Young No** Researches on the design of a pellets burner of 150 kW from agricultural waste *Gh. Lăzăroiu, L. Mihăescu, I. Pîşă*, D. Bondrea, G. Negreanu*
13.45-14.00	Coffee break (Hall)
14.00-15.00	Short communication session 2 (Room A) Co-gasification of coal and municipal sewage sludge to produce methanol *Danijela Urbancl*, Marko Agrež, Jurij Krope, Darko Goričanec* Adoption factors of environmentally sustainable energy technologies in different countries: focused on residential heating systems *Diana Londoño-Pulgarin*, Luis Gabriel Agudelo-Viana, Francisco Muñoz-Leiva, Esmeralda Crespo* Assessing social acceptance of wind energy through policy comparative analysis *Cecilia Nardi*, Marina Penna, Laura Gaetana Giuffrida, Elena De Luca* Symmetric electrodes for supercapacitor applications based on Zn:Mn oxide spray deposited thin films *J.J. Peinado, M.C. López-Escalante*, A. Brito, E. Navarrete-Astorga, D. Solis, L. Dietmar, J.R. Ramos-Barrado, F. Martín* Efficiency modelling of complex planetary mechanical transmissions used in renewable energy systems *Mircea Neagoe*, Radu Saulescu, Codruta Jaliu, Olimpiu Munteanu*

	Experimental research and simulation of computer processes of heat exchange in a heat exchanger working on the basis of the principle of heat pipes for the purpose of heat transfer from the ground *Łukasz Adrian*, Szymon Szufa, Piotr Piersa, Krystian Kurowski* Smart cane with solar energy supply for the welfare of people with visual disabilities *Daniel Icaza, Luz Cardenas** Energetic, exergetic, environmental and economic comparison between serial and parallel schemes of hybrid solar gas turbines *Sofía Rodríguez Pita, Javier Rodríguez Martin*, Celina González Fernández, Susana Sánchez-Orgaz, Ignacio López Paniagua* A new form of decentralized energy: lessons from the WiseGRID project *Rafael Leal-Arcas** Low carbon Arctic smart community: the ultimate case study of an Arctic Renewable Energy Perspective *Gisele M. Arruda**
15.00-15.45	Panel discussion (Room A)
15.45-16.00	Closing session (Room A) - Award ceremony (1) Best conference lecture (2) Best conference lecture by student

* - speaking author

KEYNOTE LECTURES

RESRB2019.0001

Business model valuation for emerging grid-scale storage technologies

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Abstract

Reducing total cost of ownership of energy storage (ES) systems over the past decades has attracted interest from system operators and technology vendors across the transmission- & distribution-connected, and customer-side electric grid. There are significant benefits that grid-scale storage technologies offer to renewable sources of electricity, however, there is a lack of appropriate valuation frameworks to quantify their benefits from planning, installation, demonstration, and full commercial operation.

Building upon existing valuation tools and a novel typology of business models for adopting grid-scale storage technologies, the scope of this presentation is to support cost-effectiveness of ES use cases by performing detailed cost-benefit and business model analyses. Specifically, we assess the value of ES for a range of grid services in different market structures. The complexity of adopting ES can be attributed to the wide variety of technology choices, diverse application services along the electricity value chain, lack of understanding of business models at utility and end user side, and complicated ownership or revenue structures which make the choice of appropriate storage technology difficult. The actual benefit of storage depends strongly on location, market structure and type of grid services provided by various energy storage technologies. A generalized cost-benefit approach for evaluating ES technologies is used to assess storage requirements and value originating from the location-specific needs of grid operators and planners. Moreover, the valuation model clearly identifies monetization and cost-benefit ratios of relevant grid services, where various business models (utility-side, service contracted and IPP models) are examined in detail.

Keywords

power grid; business model; energy storage

RESRB2019.0002

Opportunities and challenges of renewable energy utilization for power generation

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Abstract

It is expected that demand for electricity will increase rapidly in the foreseeable future with population growth around the globe. The increase in demand dictates the need for increase in generation capacity, much of which is expected to be in the form of emission-free renewable energy power generation, including the highly heterogeneous energy sources such as wind and solar.

This presentation evaluates the potential of several different renewable energy resources for power generation with a focus on the potential energy of sun for solar Photovoltaic and solar heat power generation, and solar heat for hydrogen production. The opportunities and challenges associated with the use of sustainable, but variable renewable energy-based power generation sources will be discussed. Furthermore, novel artificial-intelligence-based power management methods for mitigating the variability and improving reliability and resiliency of multi-source renewable-energy-based microgrids to optimize their production - while reducing emission - will be presented. Lastly, a vision for a future renewable-energy-based Hydrogen-economy society and its business aspects will be presented.

Keywords

renewable energy; microgrid, power management, hydrogen economy

ORAL LECTURES

RESRB2019.0003

Photovoltaics design and synergy with landscape: multifunctional land use nexus between renewable energy production and water supply

Teodoro Semeraro[1,*], Alessandro Pomes[2], Amilcare Barca[1], Cecilia Del Giudice[3], Marcello Lenucci[1], Roberta Aretano[4], Alessandra Scognamiglio[5]

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Abstract

European policies to decarbonize economic growth (Directive 2001/77/CE), have pushed the implementation of renewable energies driving, indirectly, a process of deep transformation of the landscape consequent to land use changes, i.e., from agricultural crops to photovoltaic systems (PVs). Therefore, an intrinsic paradox is in European policies: actions aimed to reduce the emission of greenhouse gases thus mitigating climate change at global scale, can produce transformations of land use that have negative effects on landscape, biodiversity, human wellbeing as well as on the same climate changes at local and global scale. For this reason, the attention towards their impact in terms of land use and land transformation has been growing, as well as concerns about landscape and biodiversity preservation and losses of ecosystem services. Currently, the design of PVs is majorly focused on the management of the full spaces, that is where the panels are positioned, without giving importance at design of the "pore" space, that is "the space around" or "the space in between" the modules. The design of photovoltaic systems mainly considers engineering aspects. this is due to a design gap between engineering solutions for the production of renewable energy and ecological or landscape issues. In this perspective, we propose to apply design approach of PV versus multifunctional land use creating a nexus between renewable energy production and enhancement of ecosystem services. This is done through a study of a new pattern for photovoltaics, in which energy generation is coupled with other ecological functions. The project has been developed adopting a transdisciplinary approach in order to involve a management system for taking into account the main economic, ecological and social aspects while avoiding trade-off among them.

Our exemplary case for this condition is located in the Apulia region, Southern Italy, because in the last few years there's been going the full-scale competition for the use of land between agriculture and renewable energy production. Nowadays, Apulia Region has more installed photovoltaic capacity than any other region in Italy. Apulia is affected by many environmental issues: groundwater supplies are stressed by increasing demand (specially, in the summer season, for tourism increased demand), as well as declining runoff and groundwater recharge. This greater consumption of water is linked with some sewage treatment issues. Considering these environmental issues, the project describes the study of a spatial pattern configuration of the photovoltaic panels and vegetation in a synergic domain with habitat or ecosystem, useful to develop ecological functions that support specific ecosystem services. The PV is designed as wetland that can introduce in the landscape direct ecosystem services, e.g. waste treatment and fresh water supply and is considered a greenhouse gas sink as CO_2 that is

removed from the atmosphere and stored in the soil carbon pool. Indirectly, ecosystem services like raw material, habitat/refugia and education might be developed and/or derived. Such PV plants represent a synergistic strategy to respond to Climate Change impact involving energy, water and land use, following different European policies and goals to contribute to the implementation of the 2030 Agenda and towards achieving the Sustainable Development Goals. The development of this green project reduces the management costs of photovoltaic farms, increases the energy productions, increases the possible revenues by developing secondary economies and, at the same time, enhances the ecological value of the areas. This project hints a new framework of environmental aspects that should not be treated only as potential impact of human activity or as mitigation strategies, but as an active part of the design. Naturally, a cultural approach to plan and design PV is implied, shifting from a “passive management of environmental impact” (design actions that increase the cost of the project to reduce the impact on the environment), to an “active management of environmental impacts”: design actions that transform the environmental impacts into new economic opportunities based on the increasing of ecological and social benefits.

Keywords
green infrastructure; ecosystem services; land use; waste water treatment; water reuse; multifunctional land use; photovoltaic; renewable energies

RESRB2019.0004

Time-dependent model of solar thermoelectric generators for enhancing conversion efficiency

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Abstract

In this study, the model of solar thermoelectric generators (STEGs) has been constructed to investigate the performance of STEGs via the finite-element method. For enhancing the conversion efficiency of STEGs, the effects of solar-selective coating and parallel-stacking arrangement have been modelled. The simulation results show that the higher the absorption and the lower the emittance of solar selective coating, the higher the voltage generated by STEGs. Meanwhile, the simulated conversion efficiency of 11 stacked STEGs with the designed solar-selective coating reached 8.4%, which was 4.9 times of that of the single STEG.

Keywords

solar thermoelectric generator; modelling; solar-selective coating; thermally parallel stacking

Acknowledgments

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RESRB2019.0005

To study the effect of air gap on delivery temperature of a novel batch solar water heater with CPC reflector using multi linear regression tool in (SPSS)

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Abstract

In India, in spite of the efforts made by MNES, IREDA and other Government of India and Private agencies the concept of Solar Water Heating for domestic purposes is not widely accepted. The reasons being high first-time capital and installation cost, although operating cost is negligible, it requires close monitoring as operating cost increases with poor up keeping and maintenance. A batch solar water heater with a single storage cum absorber unit with no separate storage tank proposed. Also, this solar water heater is distinct in design with improved solar fraction achieved with a compound parabolic reflector, as concentrator, unlike flat plate collectors (FPC's) and with an air gap introduced on the side walls of the collector gives improved heat retention. For prediction of thermal performance of the collector, the experiments were conducted under the clear sky on the open terrace in Delhi, (India), as recommended by ASHRAE 93 – 97 and ISO 9458[2] for outdoor tests. Studies have been made to know the effect of temperature of air in the gap on system performance for both summer and winter seasons. The multiple regression tool using SPSS was used for model analysis, which predicted improved system performance and good heat retention capability. The detailed studies have established that the air in the gap acts not as a thermal barrier alone, but the temperature of air increases as the day progresses. This reduces the temperature gradient between system and surrounding, and the system is capable of delivering hot water even after dusk with reasonable hot water available the next morning also. To postulate the performance in summer days, the summary output of 16 days observations, inclusive of both months, March (beginning of the advent of summer in Delhi) and April is analyzed. Based on the F-significance level which has a value of 0.0041 in April and 0.0038 for the entire period, means at 95% confidence level, the model is statistically significant. However in severe winter, especially in the month of December, the air gap does not serve the purpose it is intended, necessitating the use of an auxiliary heater. But on combining with good sunny days of December and the month of October 16 observation results are tabulated and summary of the output, obtained by MLR analysis, the R2 value is 0.707and adjusted R2 value is 0.634. It is seen from ANOVA table, the significant variables (p-value < 0.05%), are IT and temperature of air gap and predicts good model fit. It is observed that there is significant improvement in system parameters compared to conventional FPC system employed for households. This heater is simple in design, occupies less space, being a passive system is environment-friendly, also economically viable, as it eliminates the cost of pump and other auxiliaries, and best suited for domestic purpose.

Keywords

batch heater; households; concentrator; air gap; MLR tool

RESRB2019.0006

Infrastructure assessment through solar energy harvesting

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Abstract

Pavements accumulate and dissipate solar energy on daily cycles. The increased heat absorbed in pavement has many detrimental effects, including accelerated degradation of pavement, heat island effect, urban warming, increased cost to transportation agencies, increased costs for cooling nearby inhabited structures, and possibly contributing to climate change. Various technologies are available to reduce the extreme temperatures in pavements and harvest the energy for productive applications such as reducing pavement failure due to extreme hot temperature and deicing of bridge deck and roadways. Solar energy recovery from pavements has the potential to provide many substantial benefits such as extending the service life of pavements, improving the air quality, lowering impacts to the climate, and producing energy.

The URI research team recently performed an experiment about thermal heat extraction from asphalt pavement using embedded conductive pipes. The experiment was possible to extract heat from pavement and raise the temperature of water. However, it had been realized a few sources of error in the previous experiments. The follow-up experiment found that the pump accounted for approximately 50% of the heat inputted to the water. To correct this, the contribution of the heat from the pump will be accounted for in the future experiments. Future experiments plan to calculate how much water is required for this small-scale experiment to accurately portray a larger scale life size application.

To further increase the accuracy of the experiment, it was determined to use type k, exposed tip fiberglass thermocouples. The previous experiment in 2012 recorded the temperatures of each layer of the apparatus by hand every hour for 16 hours straight. This introduced human error into the experiment as recording temperatures by hand for such long hours can create human error. This is also inaccurate because the temperature of the sample is only known once per hour while temperature changes can happen rapidly between that time frame. To combat these problems the TC-08 eight channel thermocouple data loggers are used along with 12 type k thermocouples. It records the temperature of each pavement layer every second which eliminates the possibility of human error from the data recording. This will give the most accurate recording of the temperatures for each pavement layer, the water temperature and the ambient room temperature.

The first type of piping investigated was copper piping because it has such a high thermal conductivity. The next piping material looked at was PEX piping which has a much lower thermal conductivity yet, is used in many conductive piping systems. Further research into snow and ice melting systems utilized in driveways in walkways shows that PEX piping is exclusively used for embedded piping as it much cheaper than copper, easier to install, more durable and more resistant to freezing according to the Plastic Pipe Institute.

The other novel approach to harvest solar energy would be the development of thermoelectric devices that would use the Seebeck effect to generate thermoelectric power from metallic and semiconducting materials. This effect has been a way to generate heat for the interiors of automobiles, with common commercial devices using p-type and n-type semiconductors. These devices were unfortunately not practical for the application at hand, in which they are costly to develop and are bulky due to nature of design of the devices. For solar extraction from asphalt a large area, low cost thermoelectric devices

need to be developed for integration into road pavements and buildings. The organic semiconducting polymers have potential and are more efficient with a higher figure of merit for this purpose. This system can be also used for a self-powered battery-less structural health monitoring system capable of processing analog voltage input from a variety of sensors.

Keywords
solar energy harvesting; asphalt pavement; embedded conductive pipes; thermoelectric devices; infrastructure assessment

Acknowledgments
The authors thank the USDOT The Region 1 University Transportation Centre (UTC) - Transportation Infrastructure Durability Centre (TIDC) which sponsored the project partially.

RESRB2019.0007

PV-integrated solar-chimney assisted low-cost self-sustained circular greenhouse for protected cultivation and floriculture

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Abstract

This paper presents a conceptualized model of a solar chimney-assisted naturally ventilated circular greenhouse. Instead of conventional rectangular shape, a circular shape is chosen which makes the greenhouse independent of wind direction and orientation with regards to the wind-induced ventilation. Pressurised fogging system is considered as the mode of distributed evaporative cooling. A circular twin-wall solar chimney is centrally mounted which is suitably sized to provide buoyancy-induced natural ventilation. The analysis reveals that the solar chimney considerably enhances the induced ventilation, several times higher than what is usually achieved in ordinary naturally-ventilated systems. During the peak sunshine hours, the greenhouse inside temperature could be lowered by 4 ^{o}C to 6 ^{o}C below the ambient temperature, employing an optimized fogging cycle. The proposed solar PV based electrical power system is hybrid in nature. Under favorable atmospheric conditions, the greenhouse loads, viz. the fogging system pump, dosing pump and lighting loads, derive their power requirement from the solar Photovoltaic (PV) array, and under cloudy conditions and during non-sunshine hours, the loads are powered from a battery bank. Solar PV panels are mounted on the canopy and have a simple tracking system.

Keywords

greenhouse cultivation; floriculture; natural ventilation; solar chimney; solar PV

RESRB2019.0008

Measuring and comparing the transmittance of soiled PV glass surfaces in terms of global solar radiation

Karim Menoufi[1,*]

[1]Beni-Suef University, Renewable Energy Sciences and Engineering Department, Beni-Suef, Egypt; [*]corresponding author email: karim_menoufi@hotmail.com

Abstract

This article presents an evaluation of the transmittance of three PV glass surfaces using a simplified approach. The experiment was conducted in Helwan City (Egypt) at the premises of the Faculty of Engineering of Helwan University. Three PV glass surfaces were placed at three different tilt angles (0°, 15°, and 30°) and left exposed to the outdoor environment without cleaning for a period of 25 days during the summer season. The relative transmittance values were quantified in terms of the global solar radiation received by each PV glass surface. The results show that the PV glass surface of 15° tilt angle is the least affected by the shading caused by dust accumulation, as it received the maximum amount of global solar radiation compared to the other two surfaces of 0° and 30°. The study concludes that it is recommended to conduct more studies and experiments in order to further investigate the impact of tilt angle on the soiling of the PV glass surfaces in that region concerning the transmittance, where the PV glass surfaces are recommended to be left exposed to the outdoor environment without cleaning for a period of at least three months in order to be able to quantify and compare the effects on a deeper level.

Keywords

PV glass; solar PV

RESRB2019.0009

Determination of the optimal water intake points for a salinity gradient energy plant on a stratified river mouth

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Abstract

When non-saline river water flows into the sea, there is an opportunity to produce renewable energy. The salinity, or osmotic, gradient existent between both masses of water and their difference in chemical potential are equivalent to that of a dam 300 m high. Pressure retarded osmosis (PRO) is one of the processes that permit to exploit this potential. On PRO, the two water streams interact by means of a semipermeable membrane, obtaining pressurized water that is used to produce work, usually through a turbine to generate electricity.

In this study, the Magdalena River, the biggest discharging into the Caribbean Sea, is considered for assessing its potential for power production via salinity gradient technology considering PRO. This river mouth is a highly stratified estuary, which means that it presents a marked salt wedge penetrating the river channel from the sea generating strong vertical salinity gradients. The extension of the salt wedge into the river is quite variable throughout the seasons, going from more than 10 km during low river discharges to almost null intrusion during high discharges. Experimental on-site data has been acquired and used to obtain a model to predict the salinity along the estuary of the river. A method is here proposed, with the objective to pinpoint the optimal location of the water intakes.

Temperature and salinity data have been gathered along the final stretch of the river, along with seasonal flowrates historic data to formulate a hydrodynamic tridimensional model to simulate the salinity profile along the river under several climatic circumstances. Simulated salinity data from the hydrodynamic model MOHID at two selected depths, superficial water (for the low salinity source) and 10 m below the surface (the high salinity source) are used to calculate the potential power extractable in those points, using a realistic approach. The distance between intake points is used to determine the pumping energetic cost associated with each particular selection of pairs of data.

The preliminary results show that this system is adequate for SGE generation, thanks to its high stratification, which enables the availability of fresh water and salt water at relatively short distances, which is very beneficial to reduce pumping costs, and because of the adequate power densities in the PRO process. Pairs of intake points with higher salinity gradient do not present the best energetic efficiency, due to higher pumping costs required, because of the longer distance between them. There is a balance to be found, by reaching a compromise between higher power production and lower pumping cost, the solution goes through finding the best locations for water intakes and the PRO plant. This is helpful in developing this growing technology, and is also applicable for any other rivers presenting stratification.

Keywords

osmotic energy; pressure retarded osmosis; river mouths; renewable energies; estuary dynamics

RESRB2019.0010

Smart Combinatorial Technology to shift the materials R&D paradigm from time/energy consuming labor to intelligent game and business for fun

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Abstract

The material discovery and functionalization have been requiring long time for skilled engineers to work on try and error routine of fabrication and characterization. With the increasing interest in multi-component materials and layered structures as represented by high-Tc superconductors and optoelectronic devices, we have invented 2-types of original solid-state thin film fabrication systems: laser MBE for nano perovskite oxide film growth [1] and its extension to combinatorial laser MBE (CLMBE) [2]. Integrated material tips with their composition, thickness, and process parameters (temperature, time, etc.) varied along x, y, and z-axis, could be made by CLMBE with the mask action programmed to address the film deposition site in synchronization with the pulsed laser sequence and power. The combinatorial nano technology was first applied to ceramics and semiconductors using a UV laser and then extended to soft materials of organic molecules, polymers, and bio-medicals by adding an IR laser for ablation (evaporation) of targets [3]. Combinatorial IR laser MBE has been verified in high throughput library formation of π-conjugated compounds including C_{60}, liquid crystal polyester, CO_2 co-polycarbonates, and salmon DNA, halide perovskite for solar cell, and metal hydrides. Now, we start interested in designing a prototype machine for the next generation. It is a material search drone MSD: based on smart combinatorial technology (SCT). Using Nd-YAG laser to cover all the range of IR-VS-UV lights, all of the soft-to-hard materials could be integrated as a library of thin film pixels with their compositions and conditions as programmed in the fabrication chamber/wing A which is connected to chambers B, C, D for characterization of the library to form an MSD composed of four wings, thus enabling not only the net-controlled high throughput R&D of multi-components materials but also big data science with IoT/AI. We plan to make MSD an innovator to the image and technology of materials R/D from hard work to an intelligent game for future SDGs society with renewable energy, healthcare, and business fun.

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Keywords

green infrastructure; innovation management; emerging materials

RESRB2019.0011

Hydrogen production by methane steam reforming over Co-Ni mixed oxides prepared via layered double hydroxides precursors

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Abstract

Hydrogen is increasingly regarded as an ideal clean for transportation, residential and industrial sectors and alternative energy source and vector for the near future. Hydrogen can be used either as a fuel for direct combustion in internal combustion engines or in fuel cells. It is primarily produced in small scale "reformers", or large scale through steam reforming reactions (hydrocarbons or alcohols). Currently, almost 60% of the hydrogen produced is generated by steam reforming of hydrocarbons. More precisely, steam reforming of methane (SRM) Eq. (1) is the most economically competitive method for hydrogen production. Normally, four moles of hydrogen are produced for every mole of feedstock; therefore SRM is advantageous when hydrogen production needs to be maximized. CH_4 is a very common hydrocarbon and a main component in biogas (33-65%). It should be noted that biogas is considered a green and renewable energy. It is originally collected from anaerobic microbial digestion of various forms of biomass (animal dung, crop waste). Biogas is now the fifth of global energy source consumption and it is considered the fossil fuel of the century. However, it can contain impurities such as halogens and sulfur that can damage the fuel cell system if no clean-up treatment is performed. Two major reactions are considered in the MSR process: The MSR itself Eq. (1) and the Water Gas Shift reaction (WGS) Eq. (2). Combining these two reactions gives Eq. (3):

$$CH_4 + H_2O \leftrightarrow CO + 3H_2 \quad \Delta H°_{298K} = 206\ KJmol^{-1} \quad (1)$$

$$CO + H_2O \leftrightarrow CO_2 + H_2 \quad \Delta H°_{298K} = -41\ KJmol^{-1} \quad (2)$$

$$CH_4 + 2H_2O \leftrightarrow CO_2 + 4H_2 \quad \Delta H°_{298K} = 165\ KJmol^{-1} \quad (3)$$

Catalysts for hydrogen production processes are mainly based on noble metals and nickel. Rh based catalysts are highly active, but their elevated cost makes them unsuitable for use on the industrial scale, unless it is possible to reduce the quantities used without impairing catalytic performances. The advantage of using Ni-based catalysts is that they are cost-effective but they are prone to form carbon. However, studies have proven that catalysts obtained via layered double hydroxide precursors are resistant to carbon deposition, and therefore could be applied to the MSR process.

This work focuses on methane conversion to hydrogen in the presence of a layered double hydroxide (LDH) catalyst in order to increase the selectivity of the desired product (H2) and reduce carbon monoxide emission and coke formation. Due to their low cost, thermal stability and high basicity, LDH can be used in the steam reforming reaction. In this study, six kinds of LDH catalysts $Co_xNi_yMg_zAl_2$ have been developed with x and y varies between 0 and 3. Several parameters were optimized in order to obtain the best catalytic activity. It has been shown that catalysts performances for the reforming reactions depend on the content of Co, Ni and Mg.Stability tests were carried out at 800°C for 12 hours with CH4/H2O/Ar of respectively 10%/30%/60% at atmospheric pressure. Prior to the tests, catalysts were reduced at 800°C under 30 mL min^{-1} of H_2 for 4 hours. All the catalysts remained stable and active during 12 hours of stability. Catalysts with high levels of Co showed a much lower quantity of carbonaceous species with no deactivation during 12 hours. The presence of cobalt improves the catalytic stability and the resistance to carbon deposition.

Keywords

hydrogen; methane; steam reforming; cobalt/nickel catalyst

RESRB2019.0012

Zero waste egg production: valorization of poultry manure by using a modeling approach

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Abstract

Egg and poultry industry need continued efforts improving sustainability and effective energy management, Fig. 1. Proposed research addresses both specific areas. Specific research questions arise: What monetary profits and operational cost reductions could be expected from valorizing manure as a source of marketable renewable energy? What environmental benefits could be expected from valorizing manure? We have developed a techno-economic model for comprehensive valorization of manure as a source of marketable and on-farm energy. We evaluated the reduction of environmental footprint associated with the introduction of comprehensive on-farm valorization of poultry manure. Executed modeling indicated that due to manure torrefaction the valorized biochar may be produced and used as a source of energy for poultry farm. It has been shown, that about 60% of biochar must be used for manure drying and torrefaction. However, 40% may be used for covering heat demand of farm houses, which increases the sustainability of the egg production.

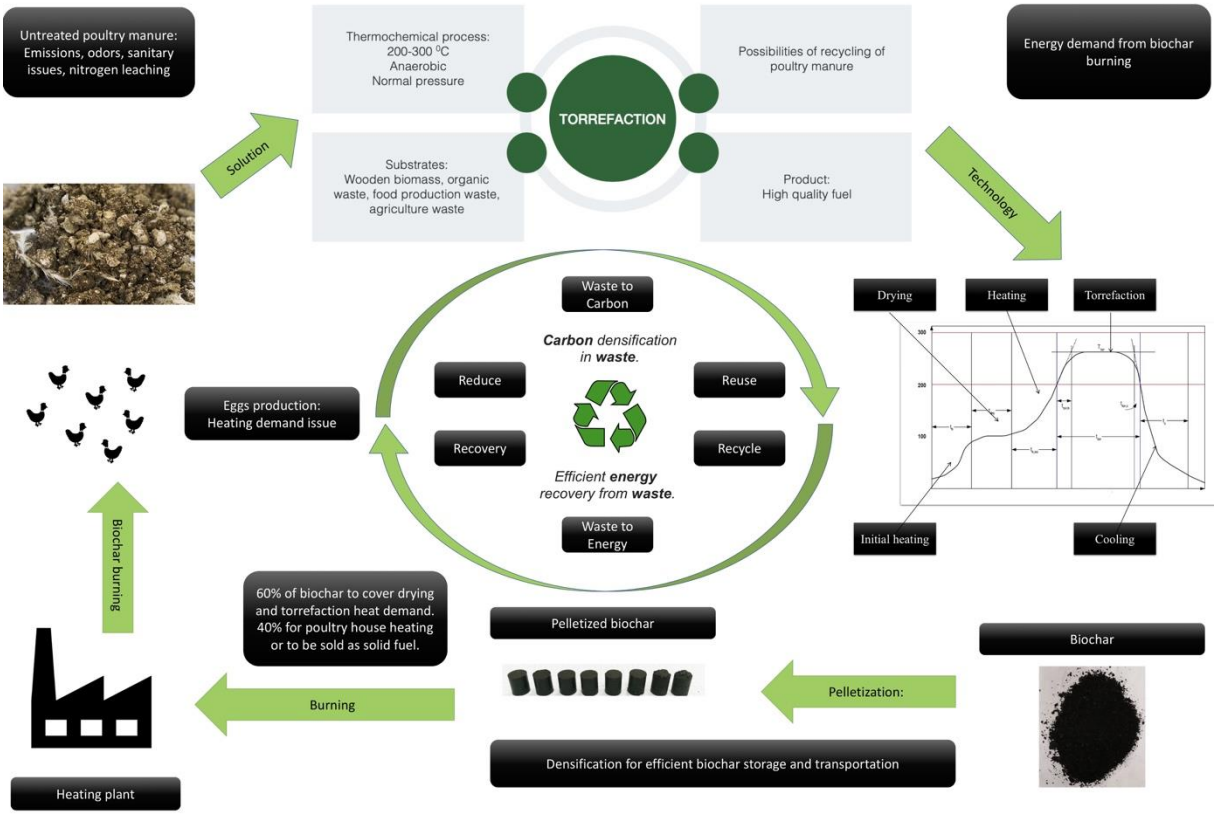

Fig. 1. The model of sustainable poultry farm with manure torrefaction and energy reuse

Keywords

poultry manure; torrefaction; biochar; sustainability; energy demand

RESRB2019.0013

Effect of organic loading rate on the anaerobic digestion of exhausted sugar beet pulp and its co-digestion with animal manures: enhancement of methane and volatile fatty acids productions

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Abstract

The anaerobic co-digestion (co-AD) process of different types of substrates could contribute to clean energy supply and a sustainable agro-industrial wastes management. Nevertheless, more recently, attention is also being paid to the dark fermentation process (namely, acidogenic anaerobic digestion) due to the interest of the carbohydrate platform in biorefinery processes.

Organic loading rate (OLR) is a key factor for the performance of the AD process and the final products that can be obtained in it. When OLR is lesser than its critical value, the methabolic rates of the different microbiological populations can be balanced and the main product of the process is a methane-rich biogas. In this case, the production of volatile fatty acids (VFAs) by the acidogenic bacteria is compensated by their transformation in acetate by the acetogenic microorganisms and the subsequent consumption of the acetate by the acetoclastic methanogenic archaea. However, when OLR reach its critical value, the rate of VFA production cannot be compensated by their transformation and removal rates. In this case, a hydrogen-rich biogas and different volatile fatty acids (mainly acetic, propionic and butyric acids) are the main products generated in the process. Therefore, the inhibition of methane production due to VFAs accumulation could be regarded as an opportunity to produce high value-added products in the biorefinery concept, which stands out the different strategies for organic wastes valorisation, besides the energy vectors.

This study aims to determine how organic overloading affects the AD of sugar beet by-products (SBB) individually and in co-digestion with livestock manures for methane production. Moreover, a deep analysis of the behavior of the reactors operating at higher OLRs inducing VFAs accumulation has been undertaken. Three mesophilic semi-continuous stirred tank reactors have been used. The process was successively conducted at OLRs ranged from 3.3 to 12.8 (gVS/Lr*d).

The co-digestion with manures clearly enhanced the systems performance and methane production from SBB, reaching up to 70% and 31% higher rates, respectively for co-digestion with pig and cow manures, in comparison with SBB individual digestion. Volatile fatty acids were the main products generated at higher OLRs, indicating acidification of the medium, inhibition of methanogenesis, and the high performance of acidogenesis. Critical OLRs led to an increase in VFAs by 93%, 87%, and 85%, respectively for reactors containing ESBP individually, with PM, and with CM, in comparison with the optimal OLR for biomethanation in each reactor. The findings indicate that valorization of agro-industrial wastes such as SBB by AD process could be favored by co-digestion with substrates with complementary characteristics in order to obtain high methane yields.

The use of semi-continuous reactors and different OLRs, together with the operation for a long period and a deep analysis of the process, make the study attractive for a possible large-scale approach at the industrial level.

Keywords

anaerobic co-digestion; biogas; volatile fatty acids; sugar beet pulp; livestock manure

Acknowledgments

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RESRB2019.0014

Energetic and economic comparison of agricultural biogas plants fed with silage and food waste

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Abstract

Substrates used in agricultural biogas plants play a dominant role in their energetic and economic balance. In typical biogas plant of the 1st generation (NaWaRo or its clones) working mainly with silages, the costs of substrates usually reach 35-50% of the profit from electric energy sold. This is quite independent of the financial support system in EU countries (Germany, Czechia, Italy, France, Austria, Poland, etc.). However, Poland is a specific country where the financial support system collapsed in 2012 because of extremally fast grow of co-incineration of biomass imported from the almost whole world. That is Polish biogas sector tries to find (after 2012) the feeding strategies far from expensive maize silage scenario. Many owners of biogas plants in Poland started to look for different biowaste used as a substrate in order to decrease the exploitation costs of installations.

The paper presents the comparison of different scenarios for feeding the biogas plant of the new generation which Is going to be run in Summer 2019 at Przybroda experimental farm. This installation (500 kW of electric power) was planned initially as a typical biogas plant using agricultural substrates like maize silage and cow manure. However, new technological solutions installed in this biogas plant (i.e., biotechnological accelerator) has increase wildly the spectrum of substrates which can be used for feeding fermentation process. That is why new scenarios were taken into account in order to decrease the costs of feeding and even reach a situation where profits from biowaste acquisition will increase the total profit of the biogas plant. The analysis has shown that the scenarios with re-food (out of date food from one of the biggest Polish market network) can generate the profit over 250 kEUR bigger than initially planned maize silage as the main substrate.

Keywords

biogas production; substrates; biowaste; economic balance

Acknowledgments

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RESRB2019.0015

Real biogas analysis and energetic valorisation by catalytic reforming

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Abstract

Currently, the most common energy in the world is produced by the burning of fossil fuels. However, this process contributes to greenhouse effect through the release of polluting compounds, such as CH_4 and CO_2, in the atmosphere. Actual researches are conducted towards the development of alternative, renewable and sustainable energy sources. The valorization of biogas makes it possible to exploit the energetic potential of the organic matter contained in the waste, while ensuring, by anaerobic digestion, a treatment and the return to the soil of this same organic matter.

The biogas is mainly composed of methane and carbon dioxide, along with minor products. In this context, the dry reforming of methane (1) has been investigated as a promising route providing a renewable source of energy. Methane and carbon dioxide present in the biogas can react together at high temperature to form a mixture of hydrogen and carbon monoxide (syngas) which can be later converted to clean synthetic fuel through Fischer-Tropsch processes.

$$CH_4 + CO_2 = 2H_2 + 2CO \qquad \Delta H°_{298} = +247 \text{ kJ/mol} \qquad (1)$$

Considering the endothermic nature of this reaction, the use of catalyst is essential to induce sufficient conversions. Moreover, dry reforming of methane is accompanied by secondary reactions, which may lead to the deposition of solid carbon on the surface of catalyst and thereby causing its deactivation. Thus, it is important in the choice of catalyst to take into consideration the selectivity of the latter to the production of H_2 and CO, while minimizing the occurrence of secondary reactions.

In addition to methane and carbon dioxide which are the main components, biogas also contains impurities such as sulfur compounds, nitrogen compounds and volatile organic compounds VOC. These molecules may affect the stability, selectivity and activity of the catalyst. This research is based on two main studies. First, the composition of biogas produced at a landfill and at a biomethanation center based in the north of France was analysed using different analytical methods like gas chromatography, high performance liquid chromatography and spectroscopy in order to identify and quantify the various compounds of biogas.

Second, Co and Ni catalysts were synthesized by incorporating different Co/Ni contents in a layered double hydroxide structure (LDH) in order to evaluate their activity and stability after calcination and reduction in the DRM reaction. Stability tests were carried out at 700, 750 and 800°C using a mixture of CH_4 and CO_2 in absence or presence of impurities such as toluene to mimic real biogas composition. Physicochemical characterization was carried out on the series of prepared catalysts before and after test.

Keywords

biogas; syngas; dry reforming; cobalt/nickel catalyst

Acknowledgments

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RESRB2019.0016

The impact of biowaste pasteurization on the methane yield in the fermentation process

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Abstract

Analyzing Polish statistical data on the amount of generated municipal waste and its morphological composition, it can be estimated that the potential stream of bio-waste will be approximately 3.5 million Mg per year. Taking into account logistic and economic factors in most communes in Poland, the stream of bio-waste will consist of both kitchen waste and biodegradable waste from gardens and parks. It has to be underlined that those wastes contain mainly high easily biodegradable organic matter, and the methane fermentation should be considered as a main treatment method. Kitchen waste stream can consist animal by-product, hence pasteurization is required as a fermentation pretreatment. This potentially high content of proteins (issued mainly from meat waste) creates a problem with increased ammonia nitrogen level (being the effect of organic nitrogen decomposition) which can be strong inhibition factor sharply decreasing methane production. That is why the preliminary tests of urban biowaste fermentation are essential for creating its fermentation technology for real-scale investments.

This paper presents initial study on pasteurization influence on methane, and biogas yield, as well as chemical oxygen demand (COD) and ammonium nitrogen concentration in waste eluates. Biowaste pasteurization had positive influence on fermentation process causing a 3% increase in cumulated methane production, and a 1% increase in biogas yield. COD and ammonium nitrogen concentration in eluate after pasteurization increased 44 and 86% respectively.

Keywords

kitchen and urban waste; biogas production; ammonia content; economic balance

Acknowledgments

This study was performed as part of the statutory research no. 506.105.06.00 in the discipline of Environmental Engineering, Mining and Energetics, entitled "Energetic use of waste as a method of improving the environment".

RESRB2019.0017

Kinetics of biomethane formation during multi-co-fermentation of organic waste from food industry

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Abstract

Biochar (BC) addition is a novel and promising method for biogas yield increase. Organic waste from the food industry (OWFI) including waste from the slaughterhouse (WS) is an abundant easily biodegradable organic matter with a large potential for biogas production. Up to now, research on pyrolytic BC application for methane fermentation showed a positive influence on the increase of both biogas and biomethane yields. Another source of BC, besides the pyrolysis, maybe BC produced under torrefaction conditions (low-temperature pyrolysis). As a feedstock for torrefaction, the digestate from biogas plant may be used. In this research, for the first time, we tested the feasibility of increasing biogas yield and rate from OWFI digestion by adding BC, which was produced from biogas plant digestate via torrefaction. The proposed proof-of-the concept refers to an approach of biogas plant waste transformation to BC and its recirculation gaining the higher biogas production, and waste recycling. OWFI was fermented in the presence of BC with BC/(OWFI+BC) weight ratio from 0 to 10 % d.m. Multi-co-fermentation of OWFI consisted of waste from the slaughterhouse (30 % w.m.), waste from vegetables and fruits processing (30 % w.m.), pulp from sugar production (20 % w.m.), waste from milk processing (10 % w.m.), and waste from potatoes processing (10 % w.m.) was investigated. The study was conducted during 21 days under mesophilic conditions in n = 3 trials. The content of dry mass 5 % in all variants was constant. All OWFI samples were analysed to assess the content of C, H, N, S, O, ash, VS, pH. The theoretical and biochemical biogas and biomethane potentials were determined. First order kinetics parameters of biogas and biomethane production were estimated. Conceptual mass and energy balances of the biogas plant for OWFI utilization with BC recirculation were done. The conducted experiment showed that applied mixture of OWFI has a very high potential for methane fermentation. The biogas yield from OWFI without the addition of BC ranged from 773.3. to 923.7 $Nm^3 Mg^{-1}$ VS, with the methane content between 57.0 and 57.8 % v/v. Moreover, it has been shown, that addition of BC did not influence significantly ($p<0.05$) and biogas and biomethane yields, and the kinetics of the process. However, this approach, with BC produced from digestate for recirculation to fermentation bioreactor, may high potential for application, as it utilizes the digestate itself and increases the degree of heat recovery from biogas cogeneration units.

Keywords

food waste; biochar; biogas; fermentation; torrefaction

Acknowledgments

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RESRB2019.0018

The possibility of gaining profit on a rational management of digestate

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Abstract

Renewable energy production is one of the most significant challenges of humanity at the moment. Biomass is the most popular renewable energy source (RES) on all world, making it the most prominent alternative for nuclear energy and fossil fuels. One of RES which is gaining importance is biogas production as an aerobic digestion process result. As a result of the process, the following products are created: biogas and digestate (digested pulp). Digestate has a liquid form and is usually used as a fertilizer directly. However, it should be remembered that there are other possibilities of its use. The work aims to determine the possibility of gaining profit from raw digestate from agricultural biogas plant and products based on it.

Depending on the current conditions in the RES sector, legal regulations may be stable in the longer term (e.g., Germany) or change frequently (e.g., Poland). In this case, it is important to think about other sources of income than biogas, methane, electric energy, and heat. But it's also worth noting that digestate can be a source of profits for biogas plants owners. The possibilities and profitability for sales of raw digestate and compost or fertilizer in the form of pellets were analyzed.

It can be concluded that the sale of raw digestate and fertilizers based on a solid fraction of digested pulp can bring additional income to the owners of a biogas plant. Based on the own research, scientific publications, considerations, talks with the owners of the biogas plant and fertilizer manufacturers should expect a systematic development not only the biogas sector but also the digestate market. According to the authors, ganging a profit from the sale of digestate would be one of the factors allowing to increase the profitability of the building of a biogas plant.

Keywords

biogas production; renewable energy sources; digestate; fertilizer; environmental engineering

Acknowledgments

This study was performed as part of the statutory research no. 506.105.06.00 in the discipline of Environmental Engineering, Mining and Energetics, entitled "Energetic use of waste as a method of improving the environment".

RESRB2019.0019

Construction and evaluation of a dry anaerobic digestion reactor for the degradation of solid waste from the textile industry by the use of fungal keratinolytic strains

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Abstract

The textile industry is the second most polluting industry in the world. It is of great concern and a subject to address urgently. The great challenge is to find new ways of reuse, which have made thus has as a purpose to build and evaluate a reactor dry anaerobic digestion for the degradation of solid waste from the textile industry by keratinolytic fungal strains.

23 fungal strains were isolated from samples of solid waste generated in the processing of alpaca and sheep wool from the company Inca Tops Arequipa-Peru and from cow rumen. To determine their degradation capacity, each of the strains was inoculated in basal saline medium supplemented with wool. Quantitative analyzes were carried out, resulting in the selection of 5 strains (PX, P-1, P-2, MB - 4 and MC-1), these were molecularly characterized obtaining: Aspergillus sp., *Fusarium oxysporum*, *Aspergillus* sp., *Fusarium oxysporum*, *Fusarium* sp. respectively.

An experimental dry anaerobic digestion reactor of 20 L was built, with an effective capacity of 11 L., the configuration was made taking into account the following: one-stage bach system with feed recirculation and biomass ratio of 2: 1 and room temperature.

The evaluation of the dry anaerobic digester was performed comparing the initial and final biomass, after 60 days operation time, resulting in a decrease in the percentage of total solids from 37.91% to 28.82%, volatile solids from 19.64% to 15.71%, chemical oxygen demand of 2080.19 mg / Kg at 1414.63mg / Kg and the pH of 7.35 to 7.15.

Keywords

solid waste; dry anaerobic digestion; reactor; fungal strains; degradation capacity

RESRB2019.0020

Production of biogas in a dry anaerobic digestion reactor of residues generated in the processing of sheep and alpaca wool

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Abstract

The objective of this research is to obtain biogas using a dry anaerobic reactor that treats the solid waste generated in the processing of sheep and alpaca wool, from the Inca Tops-Arequipa-Peru wool company with low water requirement.

52 bacterial strains and 15 fungal strains were isolated in anaerobic conditions. To determine the capacity of gas production, each of the strains were cultured on Sabouraud agar and thioglycolate broth supplemented with agar-agar. The gas production was evidenced by the rupture and/or displacement of the medium inside the tube, resulting in the selection of 3 bacterial strains and 3 fungal strains. These were molecularly characterized and identified: T-1 *Pseudomonas aeruginosa*; A-0 can be a new species of *Proteus vulgaris*; A-3 can be a new species of *Alcaligenes* sp; MC-1 *Fusarium* sp; MA-3 *Fusarium oxyporum*: MA-4 *Monascus rub*.

The composition and production of biogas produced in reactors of dry anaerobic digestion were evaluated with different inocula, bacteria, fungi and consortium; concluding that the reactor inoculated with the consortium has the best production and characteristics of biogas achieving 33.38%, 6%, 1.44% and 0.89 ppm of methane, carbon dioxide, oxygen, hydrogen sulfide respectively.

Keywords

solid waste; dry anaerobic digestion; reactor; fungi; biogas

RESRB2019.0021

Modelling biogas production from a closed solid waste landfill

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Abstract

Due to its economic and environmental value, biogas production from landfills has gained more interests in the last decades. The objective of this paper is to assess the amount of biogas generated from the closed landfill of Russaifah (Jordan) using different modelling approaches. The models used in the assessment of biogas are Gasim and LandGem.

According to both models, the maximum amount of biogas was reached in the year 2004, one year after the landfill closure. Gasim model gave a maximum biogas generation amount of about 4204.8 x 10^3 m^3/year, while modelling using LandGem model resulted in an amount of 4055.9 x 10^3 m^3/year. The modelling results were calibrated and validated by comparing them with two years of methane extraction data recorded on the landfill. The validation results as judged by the coefficient of determination (R^2) show that LandGim capability to predict the amount of biogas generated is little bit higher than that of Gassim, where R^2 = 0.671 and 0.651 for LandGem and Gasim, respectively. Global warming potential analysis revealed that Russaifah landfill has an annual potential of 53,500 tons of CO_2 Equivalent.

Keywords

biogas modelling; closed landfill; Jordan; global warming potential

RESRB2019.0022

Comparison of the spatial distribution of agricultural biogas plants in relation to generated power

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Abstract

Poland has one of the biggest potential for biogas production in Europe. The analyses made by the scientists from the Institute of Biosystem Engineering, Poznan University of Life Sciences have shown that amount of biowaste and agricultural waste can reach yearly almost 130 million tons, which is the equivalent of 6000 MW of electric power or over 8 billion m3 of biomethane (more than whole import of natural gas from Russia). In consequence, the potential of biogas sector is estimated between 4000 to 6000 installations with the electric power between 0.5 to 2.5 MW. The most common facilities are the 1 MW and 0.5 MW biogas plants. Probably during the next years, also the installations with those power scales will dominate the Polish market.

There are several technologies actually installed in Poland. The differences between biogas (and methane) production efficiency, used substrates, reliability and investment costs were analysed by many investors, bancs, scientists and specialists. However, there is very few information about spatial distribution of agricultural biogas plants in relation to generated power. Typically, the biogas plant with 1 MW of electric power needs the area between 2 to 3.5 hectares. But so large area influences strongly on the investment costs grow. That is why modern technologies have much compact technical solutions and need less space for the investment.

The aim of this paper was to compare different technologies of biogas production in order to find the most effective technologies in term of generated power related with surface taken by installation and whole terrain, which can be expressed in kW per m^2 of biogas plant or per entire parcel (this second parameter seems to be not so much valuable).

The analysis has shown that the differences between analyzed objects were very high. The most common parcel surface taken by 1 MW of electric power installation was around 3 hectares (+/- 1 ha). Surface taken by the installation itself (fermenters, tanks for digestate, technical buildings) take between 350 to 400 m^2. This an equivalent of 2.2 - 2.9 kW per m^2. However, new generations biogas plant can reach much higher parameter up to 6.4 kW per m^2 (case of the Przybroda biogas plant).

Keywords

biogas plant; power generation; spatial distribution

RESRB2019.0023

Novel encapsulant architectures on the road to photovoltaic module power output increase

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Abstract

Nowadays renewable energies take a relevant role in the carbon emission reduction. Between them, photovoltaic (PV) energy representing around 2% of global power output. In 2017, the cumulative solar PV capacity reached almost 398 GW and generated over 460 TWh [1]. During the last decade silicon PV technology has been focused on increment the final output power of commercial devices. At the beginning, the main work was carried out on the improvement of the silicon solar cell technology because silicon material implied the principal PV module cost. Nevertheless, at this moment a new scenario has been defined where the price attributable to free-silicon solar device components is under- going an increasing trend: from 25% in 2011 to 37% in 2017, of the final module cost [2]. This trend change justifies that non-silicon materials takes part in the power generation. Among all non-silicon materials, big efforts have been developed over the glass mainly using antireflective coatings [3].

This work is focused on the application of a self-cleaning, antireflective coating over the glass cover of commercial PV modules. This material has been applied directly over four fabricated PV modules and the study has been developed using industrial equipment.

The PV module I-V curves has been measured before and after of the coating application and after that, they have been out-door exposed to the environmental degradation in Málaga (South of Spain). The application of the coating does not lead to any physical modifications over the PV modules. The electrical characterization indicates a relevant power increment near to 1.5% per PV module has been measured just for its application. The real self-cleaning effect and the durability of the cover are under study.

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Keywords

solar energy; silicon photovoltaic module; final output power; self-cleaning coating; antireflective coating

Acknowledgments

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RESRB2019.0024

Model selection uncertainty and industrial energy consumption

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Abstract

Industrial energy consumption is undoubtedly a multivariable function. For both management and energy policy authorities it is of particular importance to find out which variables influence it in which direction. From the management point of view, this is because energy is necessary in the production process. It is a cost that should be wisely managed and at the same time is a means for generating competitiveness and realization of the company's social and environmental roles. Since energy consumption is an important source of adverse greenhouse gas emissions, from the energy and environmental policies point of view, they have to be minimized to mitigate adverse climate changes and achieve energy targets and sustainability goals. However, there is uncertainty in the model selection of final energy consumption. This paper aims at addressing this issue by applying the Bayesian model averaging (BMA) approach which uses the Markov chain Monte Carlo estimation algorithm. The focus is on industrial energy consumption in European Union countries in years 2010 and 2016.

The results suggested that economic condition framework matters when final energy consumption in the industry sector is considered. However, over time, there are changes in the significance of certain variables. In year 2016, besides gross domestic product, which was set as the focus variable, specific government programs and policies, particularly tailored to stimulate renewable energy, ensure market openness and create culture that supports sustainable energy behaviour and practices, played an important role. By contrast, in year 2010, which was still marked by huge economic challenges, other government's policies and programs had the more important role in influencing industrial energy consumption.

Keywords

industrial energy consumption; sustainable energy; model selection uncertainty; Bayesian model averaging

RESRB2019.0025

Impact of renewable energy on the environmental efficiency of electric vehicles

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Abstract

During the exploitation of the electric vehicle the most significant part of the energy is spent for the battery charge - 71,5% of whole energy for the life cycle. Production of a battery of 40 kWh consumes approximately 16,7% of whole energy for the life cycle. The energy for spare parts, transportation and recycling is approximately 11,8% of whole energy for the life cycle.

In this paper, an evaluation of the environmental impact of the electric vehicles using energy, produced from different types of power stations is done. The evaluation takes into account the emission factor (CO_2 g/kWh) of production of electric energy from renewable energy sources and fossil fuels using existing standards for the life cycle of the vehicles. As a base for comparison, the results concerning air pollutions of the conventional vehicles are used. The data for the structure of the energy mix and emission factor from EC-28 countries are presented. The mathematical models and graphical information present the influence of renewable energy on the ecological impact at separated stages of life cycle of the electric vehicles. Special attention is given to the influence of renewable energy on the production of the battery for electric vehicles as a significant factor of life cycle.

The research shows that if the generated CO_2 emissions for production of the energy decrease to 0,4 kg/kWh , thanks to the use of renewable energy sources, 24 126 kg emissions for the whole life cycle of the electric vehicle will be saved. On the contrary, if the emissions increase to 0,9 kg/kWh, the emissions for whole life cycle of the electric vehicle will exceed respective for conventional car with 20 717 kg.

The research shows that the use of the renewable energy sources can reduce the emissions from electric vehicles with 20 to 140%, compared to the coal based (lignite) electricity production.

Keywords

greenhouse gas emission; Life-Cycle Energy Analysis; electricity; fossil fuels; renewable energy

RESRB2019.0026

Case study of rural residential housing energy-efficiency gains: switching from coal to renewable energy

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Abstract

In Poland, the majority of single-family homes are located in rural areas and use primarily fossil fuels to heat space and water. Following European Commission directives, newly constructed homes must adhere to higher energy-efficiency standards. This paper examines changes in energy use and CO_2 emissions of houses using coal, natural gas, and renewable energy (RE) installations in the form of thermal solar panels and heat pumps. Despite higher initial construction costs, results show that houses with RE micro-installations exhibit a substantial reduction in energy use once occupied, while also emitting a considerably lower volume of CO_2 and other GHGs. Additionally, the reduction of solid fuel use lowers the amount of ash disposed at landfills. The limitation of the new requirements is the increase in initial investment in an energy efficient family home.

Keywords

RE micro-installation; single-family home; CO_2 emission; rural areas

RESRB2019.0027

Modelling of automatic generation control for multi-area integrated power system equipment including renewable energy systems

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Abstract

Nowadays, increasing electrical energy demand is mostly providing from different fossil sources, hydroelectric and even with the nuclear energy plants. Therefore, the importance of renewable energy sources increases day by day for cleaner environment and less emission for human being. As a result of this different energy sources, the new integration and cooperation problems are emerged for energy providers. In this study, a multi area model of Automatic Generation Control (AGC) system including both classic thermal power plants and also renewable power plants including solar and wind farms are established in MATLAB/Simulink simulation programme. These power plants in entire system are weighted according to their participation. In addition, the effects of the frequency stability of the power system according to their participation to the either primary or secondary control loops are investigated for different cases. Controlling the secondary loop of AGC for different participation cases is provided by using proportional-plus-integral (PI) controller which is optimized with Particle Swarm Optimization (PSO) algorithm. At the end of the study, the dynamic response of the model presented and interpreted in detail.

Keywords

automatic generation control; solar farm; wind farm; particle swarm optimization

RESRB2019.0028

Alternative designs on liquid-flow window technology

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Abstract

In modern cities, the worldwide trend is to go for sustainable building development, or directly to go for zero-energy building construction in the battle against global climate change. Much research efforts have been on the window glazing, since this is a particularly weak thermal element on the building facade in terms of heat transmission, leading to excessive fossil-fuel consumption. Liquid-flow window is a novel multi-glazing design concept to deal with this identified thermal weakness. A flowing liquid layer within the cavity of a multi-pane window is able to reduce the space air-conditioning load and at the same time, to reduce the hot water energy consumption. Better thermal comfort at the room space can be enhanced. Such liquid flow can be on either mechanical-flow or buoyant-flow basis. In recent years, different system designs and applications have been suggested and with their energy-saving potential evaluated. This paper firstly discusses the current design and application trends. Then a novel alternative design - the liquid-bath type - is introduced. This new approach carries the advantage of the buoyant flow concept in better water pressure control, but with substantial improvement in heat removal capability and simplified frame structure. Finally, the system thermal performance of an industrial design prototype is discussed.

Keywords

solar energy; window glazing; building-integrated thermal system; water heating; zero-energy building

RESRB2019.0029

Evaluation of the influence of three microbial strains in the composition of the biol obtained from the treatment of residues of the textile industry

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Abstract

Biol is a liquid organic fertilizer that originates from the decomposition of organic materials, such as animal manure, green plants, fruits, legumes, among others. The biol as fertilizer is a source of phytoregulators that help plants to have an optimal development, contains nutrients that are easily assimilated generating greater productivity from the crops, making them more vigorous and resistant. To obtain biol bioreactors are used, they work anaerobically, that means in the absence of oxygen.

This research was carried out with the objective of evaluating the composition of the biol by using microbial consortiums inside a reactor with an effective volume of 11 L that operated for 45 days.

For the treatment of solid waste, native bacteria were isolated from sheep wool and alpaca fiber. These were identified molecularly, obtaining the anaerobic strains Pseudomonas aeruginosa, Proteus vulgaris and *Alcaligenes* sp., which have the capacity to produce gas. In the same way, native fungi were isolated from the cow rumen and were molecularly identified as *Aspergillus* sp., *Fusarium* sp., *Fusarium oxysporum* and *Monascus* sp., which are anaerobic strains and degrade textile solid waste. With the isolated strains, three different consortia were formed; only bacteria, only fungi, bacteria and fungi. From these processes, 4 L of biol were obtained per consortium. After different experiments and parameter analysis it was concluded that the biol extracted from the bioreactor 1, which worked with the bacteria; and the bioreactor 2, which worked with the fungi, gave excellent results that improve the parameters of the standard biol. The biol obtained from bioreactors 1 and 2 has a greater amount of N-P-K (Nitrogen-Phosphorus-Potassium) that helps the growth and vegetative development forming part of proteins, chlorophyll and hormones such as vitamins. The amount of Ca (Calcium) and Mg (Magnesium) in the biol of reactor 1 and 2 resemble organic fertilizers, so it can be used in hydroponic crops since they help root growth and strengthening of the cell wall.

Keywords

boil; biodigester; microbial consortia

RESRB2019.0030

Renewable energy resources for better economics and sustainable living in rural and desert areas

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Abstract

Reliable and affordable energy is key for the socio-economic development in rural and desert communities worldwide. While energy can be used for consumption purposes such as Lighting, Access to Information, Comfort and Entertainment, productive use of renewable energy is the key enabler for SMEs and Economy to grow. The paper examines the complex interconnections between Energy - Materials - Water - Food - Building - Employment - Environment. It also discusses the implementation of renewable energy technologies to overcome some of barriers faced by rural villages and desert communities. It shows some of the special applications and approaches used over the past few decades in energy conversion, consumption and conservation to achieve poverty reduction, social justice and sustainable development. Field experiences in Basaisa projects, Egypt showed that open free dialogues with all stakeholders, site-specific education and training, appropriate local financing systems and access to knowledge are key-elements and essential factors for achieving green economy and sustainable community development. The coming decade will see a continued expansion of knowledge about renewable energy resources and its useful applications as systems friendly to the environment and as tools for economic activities, sustainable living and growth in rural and desert communities.

Keywords

renewable energy resources; economics; sustainable living; development; rural and desert communities; Basaisa; Egypt

RESRB2019.0031

New empirical production models for poplar plantations on farmland - a toolbox for improved management and planning operations

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Abstract

Interest in utilizing trees for bioenergy production has increased drastically in recent decades. Poplars (Populus spp.) are an exotic group of species in Sweden. Hybrid poplar plantations with short rotation (≤ 20 years) established on farmland in south and central Sweden, have shown promising production figures and been in focus as a future potential bio-fuel feedstock. Results from 20-year-old poplar plantations show a total production of up to 300 t d.w. ha^{-1}. Mean annual volume production is on average around 20-25 m^3. Taper, biomass- and volume models were developed for individual poplar trees. One model was developed for biomass estimations of individual stumps (including roots) and another model was developed for biomass estimation of 2nd generation coppiced poplars. We have finally studied the properties of false heartwood of poplar stems growing at 22 sites in Sweden. The models usage is non-destructive.

1) Biomass and Volume models for individual Poplar trees: The developed biomass equation uses dbh (diameter at breast height, 1.3 m above ground) as independent variable and estimates the stem, twigs and leaf fractions separately or together. One equation with dbh (D) and total height (H) as independent variables were constructed for stem volume estimation (V) and compared with a number of published equations.

2) Biomass models for Poplar stumps and 2nd generation coppices: There are two ways to manage the remaining stumps after harvest: 1) Excavation, or 2) Management of sprouts established on stumps. Models for estimation of individual stumps and coppice biomass were developed. Biomass production of 1000 excavated stumps could be 45-50 t d.w. ha-1. The stump was 74% on average of the total stump-root biomass. Roots (>50 mm) made up the remaining 24%. Biomass of 7-year-old coppices on 1000 stumps could be 30-35 t d.w. ha^{-1}.

3) Taper model for individual Poplar trees: Taper models estimate diameter (d) using DBH, corresponding height (h) and total height (H) as independent variables and are useful for estimating properties of different assortments with mini diameter restrictions. The objective was to develop a simple taper equation with good ability to predict diameter at a given height and compare it with common published taper equations.

4) Models for prediction of false heartwood properties in Poplar stems: All of the sampled stems contained false heartwood. At 0 - 50 % of stem height, all sampled trees were discolored and at 90 % of stem height, 33 % were discolored. The percentage of false heartwood area by stem area was highest at 1 % and 10 % of stem height (26.6 % and 24.7 % respectively). Equations were constructed describing the correlation between diameter at breast height and the diameter of false heartwood at different stem heights aimed for stems to be used for construction. However, most of the fast-growing poplars in Sweden is expected to be harvested as biofuel.

Keywords

poplar; farm planning

RESRB2019.0032

Increased energy efficiency and renewable energy use for high temperature heating

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Abstract

High-temperature heating is identified as one of the most challenges issues at regional and local level due to the high use of non-renewable energy sources and a very low share of renewable energy sources. In order to improve energy efficiency and the use of renewable energy sources for high-temperature heating, innovative technical solutions are needed.

The aim of the research is to increase the fuel efficiency (natural gas, diesel, LPG, etc.) using renewable energy sources for high-temperature heating. The increase in fuel efficiency depends on the efficiency of CHP (cogeneration, combined heat and power system) and HP (heat pump) and can reach up to 220% in relation to LHV (low heating value) of fuel and with that equivalent CO_2 emission reduction into the environment.

The new heating system use low-temperature renewable energy sources (groundwater or any other waste heat) with a heat pump (HP). The produced heat is used for preheating the return water of the high temperature heating system to a maximum of 60°C and then water reheating at the required temperature with cogeneration system (CHP). For the HP compressor operation, the use of electricity produced by CHP is predicted.

The implementation of new heating system will reduce the dependency on the import of primary energy and will have positive effects on better air quality.

Keywords

renewable energy sources; high temperature heating; cogeneration; heat pump; energy efficiency

RESRB2019.0033

Pentanol as biofuels in compression ignition engines

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Abstract

The utilization of higher alcohols or long-chain alcohols such as pentanol, hexanol, octanol, decanol, dodecanol, and phytol has recently received considerable attention as alternative fuels for diesel engines. Of these higher alcohols, the application of pentanol to CI engines will be reviewed.

Pentanol ($C_5H_{11}OH$) is one of higher alcohol with five carbons in its structure and has big potential as a blending agent with diesel fuel because of its high energy density, high cetane number, better blend stability and less hygroscopic nature than other widely studied lower alcohols such as methanol, ethanol and butanol.

Because of great potential as a blending component of pentanol, binary blends such as diesel/pentanol and biodiesel/pentanol, ternary blends such as diesel/biodiesel /pentanol were widely studied in the conventional diesel engine. The studies related to binary blends include diesel/pentanol, biodiesel/pentanol, kerosene/pentanol, SVO/pentanol blends. The ternary blends can be classified into four categories: diesel/biodiesel/pentanol. diesel/SVO/pentanol, biodiesel/SVO/pentanol, and diesel/pentanol/methanol blends. Quaternary blends of diesel, biodiesel, SVO, and pentanol was also investigated. Very few information related to the utilization of pentanol in advanced CI engine is available in the literature.

The pentanol/diesel blends coupled with EGR technology could simultaneously reduce NO_x and soot emissions from CI engine. Further, diesel/pentanol blends generally produced higher CO and HC emissions than diesel fuel. However, CO and HC emissions were significantly reduced by mixing the cetane improver with the blends. Up to 45%~50% n-pentanol/diesel blends can be safely used in diesel engines without any engine modification or any additive. However, in terms of kinematic viscosity, lubricity, and oxidation stability of pentanol/diesel blends, the use of pentanol should be limited to concentrations below 10%. For ternary blends, diesel/biodiesel/pentanol blends were mainly investigated by the researchers. The emission characteristics in terms of CO, HC, NO_x and smoke opacity showed the different trend according to the pentanol percentage in the ternary blends, particularly less than 10% or more than 10%.

Keywords

pentanol; compression ignition engine; chemical kinetic mechanism; pentanol/diesel blends; ternary blends; liquid biofuels

RESRB2019.0034

Researches on the design of a pellets burner of 150 kW from agricultural waste

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Abstract

Within the company Enache MORARIT from Husi, county of Vaslui, Romania, research has been carried out on the use of bio-fuels for the production of thermal energy. The research was carried out with a team of specialists from Politehnica University of Bucharest. After remarkable results in the use of grain briquettes in boilers up to 500 kW, researches have been extended to the aspects related to the use of the pellets.

Regarding the use of pellets, it was envisaged the realization of horizontal burners for high thermal power. Regarding the use of pellets, it was envisaged the creation of horizontal burners for high thermal power. As the grain pellets led to sensitive slugging, the pea and rapeseed strains were used.

This research is about creating a horizontal pellets burner, of 150 kW, to underpin future projects of higher power. The previous generation of pellet burners was cooled by water with a much lower efficiency.

The burner has been experimentally tested on a stand that simulates an un-cooled furnace. The obtained results were confirmed by those obtained by modeling and numerical simulation. The paper, by its essence, allows highlighting the links between the elements of computing and those obtained from experiments and mathematical modeling. This paper contributes to creating conditions for a more detailed approach in the future.

Keywords

biomass; pellet; agro-waste

SHORT COMMUNICATIONS

RESRB2019.0035

Novel Ni/Ce_xKIT-6, Ru/Ce_xKIT-6 and Ni-Ru/Ce_xKIT-6 catalysts for the dry reforming of methane: a comparative study

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Abstract

Nowadays, hydrogen is considered as the most promising energy vector of the future as it is readily available, less polluting, and can be efficiently converted to electricity in fuel cells. The dry reforming of methane (DRM) is one of the most prominent routes to produce hydrogen. Among all catalytic reactions, DRM stands out as it allows the simultaneous conversion of CH_4 and CO_2, two of the most abundant greenhouse gases that are causing the climate change problem. For it to be efficient, the DRM reaction should be performed in the presence of a catalyst. In this work, KIT-6 ordered mesoporous silica was chosen as a catalytic support. It was doped with cerium oxide in order to improve its redox properties which in turn improve the interaction of the support with the active phase. Nickel and Ruthenium were chosen as the active phases in this study. To our knowledge, no studies have considered the usage of such catalytic materials in the DRM reaction. The synthesis of the 3 catalysts Ni/Ce_xKIT-6, Ru/Ce_xKIT-6 and bimetallic Ni-Ru/Ce_xKIT-6 (x=60%, 30%, or 15%) was done using the wet impregnation technique. The percent of nickel and ruthenium in all catalysts was fixed at 15 wt% and 1 wt% respectively. All catalysts were calcined at 550 °C and characterized before and after catalytic testing.

N_2 adsorption/desorption isotherms indicated the presence of a mesoporous structure that is common to all the catalysts. A bimodal pore size distribution was observed. This latter became narrower with the increase of Ce content probably due to pore blockage. The XRD analyses revealed the presence of the ceria fluorite, NiO and RuO_2 structures after calcination. The H_2-TPR study proved the incorporation of cerium oxide in the pores of the mesoporous support especially at high Ce loadings. It also showed that some NiO and RuO_2 oxide species are free within the catalysts. The catalytic performances improved with the Ce content. Ni/Ce_xKIT-6 and Ni-Ru/Ce_xKIT-6 catalysts showed the highest CH_4 conversions (up to 94%) comparable to the thermodynamic theoretical values. Although slightly less active, the Ru/Ce_xKIT-6 catalysts were the best performing as they were the most stable over long runs on stream.

Keywords

dry reforming; methane; KIT-6; cerium; nickel; ruthenium

RESRB2019.0036

An expert-based technology evaluation for assessing the potential contribution of energy technologies to Italy's decarbonisation path

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Abstract

A reference catalogue of the energy technologies was realised in the framework of the 'Technical Board on Decarbonisation of the economy', established by the Italian Presidency of the Council of Ministers. The catalogue is intended to support policy makers in addressing the issues related to the decarbonisation of the economy, from the viewpoint of balancing the three pillars of the energy trilemma: environmental sustainability, energy security and affordability. Thirty-six technologies have been identified and grouped into six different categories: Generation Technologies with fossil sources, Co-Generation Systems, Renewable Energy Technologies, Energy Storage Systems, Energy Efficient Technologies, and Other Technologies. A standard datasheet containing quantitative and qualitative information regarding Technology Readiness Level (TRL), efficiency, environmental and economic impact as well as policy aspects was compiled to provide an evaluation of each technology by experts selected at national level. The catalogue gives a snapshot for the year 2017 and provides information on technologies with high decarbonisation potential, although still in the development phase, which could offer an important alternative to the country, not only in terms of climate mitigation but also of industrial development. In the finalized version, the information datasheet is thus an example of aggregation and synergy among the Italian entities involved in the energy sector providing shared and validated information. In order to assess the potential development of energy technologies in Italy, some quantitative analyses were performed. The data matrices of TRL, CO_2/MWh avoided emissions, number of Italian entities involved in production and /or R&D of technologies and centres of excellence were elaborated by using statistical tools. Cluster Analysis was performed to find associations between TRL and the number of companies involved in energy technologies in order to highlight emerging groups of technologies. The relation between TRL (medium value and range) and CO_2 avoided emissions was displayed by a Scatter Plot diagram. Network analysis was performed to highlight the existing interconnections between centres of excellence and the technologies with high potential of development in relation to CO_2 avoided emissions. Moreover, the mapping of the distribution of Italian companies and centres of excellences by region was realised. Statistical analysis suggests that Italy has a high potential of development of energy technologies, especially concerning RES and Energy Storage Systems. Research and development facilitated market penetration of some technologies, involving several sectors of the Italian Industry. The network analysis highlighted the central role played by Research Institutions and Universities in the development of energy technologies as well as the numerous connections between centres of excellence and the most promising technologies, some of the latter belonging to more specialized sectors with fewer entities involved. The maps of companies involved in R&D activities and centres of excellence show a territorial distribution that is not completely homogeneous. In broader terms, the quantitative analysis provides suggestions to policy makers on how to foster the development of technologies by supporting either the research and development stage or the industry sector. The proposed methodology contains characteristics of replicability in other territorial contexts. In perspective, technology evaluation should not ignore the assessment of social and economic aspects, especially employment, by selecting specific indicators (e.g. job opportunities); this will lead to a technology evaluation oriented to overcome the new

challenges of the energy transition.

Keywords
technology evaluation; decarbonisation; TRL; energy trilemma

RESRB2019.0037

Co-gasification of coal and municipal sewage sludge to produce methanol

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Abstract

Municipal sewage sludge is a renewable resource that can be used to produce synthetic fuels. Simulations regarding the co-gasification of coal and municipal sewage sludge within entrained-flow slagging gasifiers (two 500 MWth) were performed using AspenPlus software. This study presents a comparison between the gasification of coal and the co-gasification of coal and municipal sewage sludge. The percentage of sewage sludge used during the co-gasification process varied between 10% and 30%. Methanol was produced from the synthesis gas in all cases. The comparison was based on net present values and internal rates of return. Sensitivity analyses were performed, by varying prices of sewage sludge, coal, and CO_2 tax. The results showed that co-gasification cases outperformed coal-only case in terms of net present value, while the production of methanol was slightly decreased with the increased percentage of sewage sludge in the co-gasification cases.

Keywords

gasification; municipal sewage sludge; coal; simulation; methanol production

RESRB2019.0038

Adoption factors of environmentally sustainable energy technologies in different countries: focused on residential heating systems

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Abstract

The international community has highlighted the seriousness of global warming, the deterioration of the ecosystem and the depletion of non-renewable resources, which is why sustainability has taken a key role in the global agenda. Because the achievement of the Sustainable Development Goals (SDGs) of the UN is sought, different strategies, business practices and environmentally friendly systems, such as clean energy technologies (CETs), have emerged. This can be achieved with long lasting changes in the society´s lifestyles supported by the global public policy development plans related with an international sustainable vision.

Despite efforts to promote environmental sustainability and the adoption of CETs, their diffusion is still limited, while fossil fuel-based energy systems remain predominant. The literature suggests that the beliefs and attitudes of individual consumers play a crucial role in the diffusion and adoption of CETs, since their final action will depend on cognitive, affective and behavioral components based on environmental concern. Therefore it is necessary to know: which are the factors that influence the purchase and adoption of these environmentally sustainable energy systems.

Due to the above, the present study contributes to previous research related to the adoption behavior of clean and renewable energy used for residential heating. A CET´s purchase model is supported by this empirical work based on logistic regression where the influence of different factors and emotional/cognitive pro-environmental mobilizers were identified and tested in accordance with the international vision of sustainable development; the individual´s environment protection perceptions and beliefs are activated whenever the purchase and adoption of sustainable thermal energy technologies is proceed. The study results provide a basis for the diffusion strategies of this type of domestic systems on the market as part of the private and public organizations business management; this also contributes to the a accomplishment of the SDGs worldwide.

To carry out this research, 868 owners of single-family houses over 19 years old of six different countries (Spain, United States, United Kingdom, France and South Africa) were surveyed. Logistic regression methodology (Logit-Probit) was used in order to analyze the proposed purchasing behavior model towards environmentally sustainable energy technologies for heating in each country. The theoretical model was tested and validates with SPSS and STATA software.

Keywords

environmental sustainability; clean renewable energies; renewable heating; adoption and diffusion strategies; consumer behaviour

RESRB2019.0039

Assessing social acceptance of wind energy through policy comparative analysis

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Abstract

A comparative analysis on the policies and regulatory measures in the light of procedural justice and distributional justice was realised to assess different countries arrangements and give policy insights to deal with wind energy social acceptance. The study was undertaken within the framework of EU H2020 WinWind project aiming at enhancing the socially inclusive and environmentally sound market for wind energy. Developing public engagement and involvement processes to address community disagreement does not only concern actions to counter the negative impacts of wind installations. It deals with a cultural approach oriented to build knowledge, involving interaction and listening, with the goal of generating mutual benefit. In several countries, the current institutional arrangement for wind power plants siting are focused on simplifying and shortening the authorisation procedures, without adequately taking into account public participation. The adopted methodology evaluated the main stages of the decision-making processes of WinWind partners (Germany, Italy, Latvia, Norway, Poland and Spain), following different steps. At first a survey was delivered to experts to assess the public involvement expected by the current regulations specifically related to three issues: the strategic planning of wind power plant siting at national level, the authorization procedures and the national support schemes. The qualitative data collected have been analysed and compared, in the light of evaluating three levels of public involvement: information, consultation and participation. Despite the differences among countries characteristics and institutional arrangements, the results obtained suggest policy recommendations suitable for all participating countries. Hence, the methodology used was consistent with the analysis and useful for similar comparative analysis. Two main results emerged. The absence of a spatial development plan for wind farm siting is harmful in terms of practical issues (i.e. extended timing of the authorization procedure, institutional disputes on natural and cultural heritage safeguard) and excludes the possibility of public involvement, affecting social acceptability. Moreover, the lack of institutionally defined spaces for participation enhances the expression of dissent and disagreement towards institutions as the only form of public involvement. Thus, the policy recommendation regarded the setting of a spatial development plan containing institutionally defined tools and regulatory measures for a concrete public involvement. Such measures to foster public consultation within the authorisation procedures and support schemes should not only include information to the public, but also the possibility of an effective participation. Social acceptance, in fact, could only be achieved through an effective and institutionally regulated public involvement, from which directly benefit both processes and relationships between citizens and institutions by decreasing the occurrence of dissent demonstrations and giving the correct importance to trust and dialogue with the institutions.

Keywords

wind energy; social acceptance; decision-making; public involvement; participation

Acknowledgments

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RESRB2019.0040

Symmetric electrodes for supercapacitor applications based on Zn:Mn oxide spray deposited thin films

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Abstract

Supercapacitors are energy storage devices characterized by its high-power density, fast charge-discharge rate, long cycle life and wide thermal operating range which make it one of the most promising systems for the future. They can be prepared by a wide variety of materials (with and without carbon, transition metal oxides (TMOs), nanostructures, thin films, etc.) together with a broad material preparation method (electrospun, hydrothermal synthesis, spray pyrolysis, etc.). Nevertheless, among them just a few materials and deposition techniques can successfully be industrial transferred because they have to fulfill three main requirements: environmental safety, low-cost materials and systems, and easy industrial scale. One promising combination is TMOs prepared by spray pyrolysis.

This work is focused on the characterization of electrodes prepared by spray pyrolysis using aqueous zinc and manganese solutions with two different Zn:Mn precursor ratio: 0.025:0.05 (sample A) and 0.0025:0.005 (sample B) over ITO/glass substrate heated at 400ºC during 2 minutes. The electrochemical characterization shows that B sample presents higher specific capacitance than A sample: 377 F g^{-1} and 288 F g^{-1} at 10 mV s^{-1} respectively. These values are higher than others previously published: 150 F g^{-1}[1] and 209 F g^{-1}[2]. The galvanostatic charge-discharge test shows the same behaviour: 350 F g^{-1} and 275 F g^{-1} for B and A samples respectively, while bibliography reports values between 182 F g^{-1} [3] and 274 F g^{-1}[4]. Regarding electrochemical stability and long cycle life up to 4000 cycles, both samples present suitable behaviour with a high specific capacitance retention (83%-95%). The measured differences can be related with samples structure because XRD analysis reveal a signal located at 35° related with $ZnMn_2O_4$ compound on A sample which is not detected on B sample.

Obtained results prove that it is possible to fabricate TMOs electrodes by aqueous spray pyrolysis with easy transferred industry. Moreover, the capacitance values are greater or at least in the same order than bibliography results. Future work will be focused on the built up of supercapacitor devices and their characterization.

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Keywords

supercapacitor; spray pyrolysis; electrochemical; transition metal oxides; manganese oxide; zinc oxide

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RESRB2019.0041

Efficiency modelling of complex planetary mechanical transmissions used in renewable energy systems

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Abstract

The recent upward trend in raising the energy share from renewable sources has led to a significant increase in scientific and practical interest in the design and development of efficient renewable energy conversion systems. Thus, in the production of green electricity, wind and hydro systems are two of the most dynamic areas addressed by researchers whose main objectives are to increase their conversion efficiency and maximize the use of the available renewable energy potential. In this context, many innovative concepts of wind turbines / hydro systems have been developed, especially in the range of medium and high powers, which usually include mechanical transmissions in order to increase the speed and to transmit the motion from input rotors to electric generators.

Although there are numerous outstanding results in the literature, the mechanical transmissions with simple structures, obtained by serial connection of gear mechanisms with fixed or mobile axes, are generally implemented in practice. These transmissions have the disadvantage of larger overall size and lower efficiencies compared to systems obtained by parallel connection of the component mechanisms. Consequently, the paper deals with the complex mechanical transmissions obtained by parallel aggregation of planetary gear mechanisms intended for integration especially in wind turbines or hydro systems with one or two rotors and with a classical (with fixed stator) or counter-rotating (with mobile stator) electric generator. In this respect, the mechanical transmissions are systematized into several categories, mainly depending on the number of inputs (i.e. the number of rotors) and outputs (i.e., 1 output for the classical and 2 outputs for the counter-rotating electric generator). Further on a generalized kinematic and static modelling of these transmission categories is proposed, which allows the establishment of efficiency generalized relations by considering also several adjustment parameters of the conversion system. These generalized results can be applied to planetary mechanical transmissions operating either as speed increaser or speed reducer. The paper results are presented as generalized algorithms and analytical relations for calculating the efficiency and kinematic ratios of complex planetary transmissions and are useful to researchers, designers and developers of renewable energy systems with higher performances.

Keywords

renewable energy system; wind turbine; hydro system; speed increaser; planetary transmission; kinematic modelling; static modelling; efficiency; kinematic ratio

RESRB2019.0042

Experimental research and simulation of computer processes of heat exchange in a heat exchanger working on the basis of the principle of heat pipes for the purpose of heat transfer from the ground

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Abstract

The article presents the results of experimental research and simulation of computer processes of heat exchange in a heat exchanger working on the basis of the principle of heat pipes for the purpose of heat transfer from the ground. The article presents the results of experimental tests at the experimental stand and computer simulations of the effects of heat exchange and phase transformations, both on the heat supply side and on the heat pickup side in order to build them from above. a heat source heat exchanger that allows efficient transport of heat from the ground. The final result of the conducted tests are the results of measurements and characteristics of heat exchange processes and the actual efficiency of analyzed heat exchangers, such as heat pipes made of copper, 1780 mm long and 18 mm in diameter. One of the main assumptions was the analysis and evaluation of the heat pump's efficiency for various working factors and related phase transitions as well as in different temperatures in the range of 5-50 ^{o}C both on the heat supply side and heat reception. The heat streams collected and given off by the heat pipe during the operation were examined, which in the selection of the optimization criterion in the form of type and amount of working medium resulted in the efficiency of the heat pipe exceeding 90% with heat streams reaching 200 W.

The article presents research issues necessary for the analysis of the efficiency and usefulness of heat pipes as heat exchangers mounted in the lower heat sources of the central heating installation, including in air conditioning and construction engineering because the temperature range at the time of testing was 5-50 ^{o}C, which coincides with the scope of work of heat exchangers working in the above-mentioned environments. Obtained satisfactory results of experimental tests in the size of heat streams collected and given by the heat pipe at the level of 200 W and its efficiency in heat transfer exceeding 90% on the one hand enable reduction of operating costs of central heating and cogeneration devices for heat and electricity production, on the other hand they enable their ecological work, which in turn will contribute to the reduction of CO_2 emissions to the atmosphere.

Keywords

heat exchange; heat pipe, renewable sources of energy; heat pump

RESRB2019.0043

Smart cane with solar energy supply for the welfare of people with visual disabilities

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Abstract

In this article we present a design of an intelligent cane designed for people with visual disabilities, which can be charged by solar energy and the energy produced stored in batteries of small dimensions. The technology that is available today can be very useful to improve the lives of a large group of human beings who have visual difficulties. The electronic design and its main components are also presented for the assembly of the cane, and finally the prototype of the cane and the functioning tests are presented. The mechanism considers a source of autonomous solar power supply to transform it into electrical energy, implying that functions anywhere, however it is also possible to source energy from the public commercial network. In the present work of investigation also the simulations in Matlab and their design characteristics are presented.

Keywords

smart cane; automation; solar panel; battery; simulation; radiation; GPS; visual impairment

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RESRB2019.0044

Energetic, exergetic, environmental and economic comparison between series and parallel schemes of hybrid solar gas turbines

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Abstract

Hybridization of fossil fuel plants with Concentrating Solar Power technologies is becoming increasingly important, especially in countries like Spain, where solar irradiation is high. These plants enable a reduction in both fuel consumption and CO_2 emissions, offering at the same time the reliability of a fossil fuel backup. There are many examples of successful hybridization, and this study attempts to determine to what extent the position of the solar tower would affect the overall performance of the plant.

In this work, a comparison from an energetic, exergetic, environmental and economic point of view (4-E) of two different configurations is carried out. The first configuration consists of a modified gas turbine that incorporates a solar tower to preheat the air entering the combustion chamber. In the second configuration, the solar tower is placed in parallel with the combustion chamber, so the air passes through either one of them.

Thermoflex and Equation Engineering Solver models of both have been simulated developed. These models provide detailed annual calculations considering that the solar tower is working or out of service. When the solar tower is non-working, the power plant operates as a conventional gas turbines.

Results obtained show that the energetic efficiency of both configurations diminishes when the solar tower is used, from 0.29 / 0.28 when the plant works in fossil mode, to 0.22 for the series solar tower, and a further 0.19 for the parallel solar tower.

For the exergetic analysis, both exergetic destructions and efficiencies are calculated. A slight reduction in the overall cycle efficiency occurs when the solar tower is used, from 0.277 to 0.235 in the series solar tower configuration; and from 0.267 to 0.217 in the parallel one.

The environmental analysis yields a reduction of 11.3% of CO_2 emissions for the series configuration; and an even further reduction of 17.6% for the parallel one.

The Levelized Cost of Electricity (LCOE) was used to compare all four combinations from an economic point of view. In this analysis, the differences in solar tower height and field sizes, as well as in fuel consumption become relevant. Additionally, the variation of the LCOE with the price of the heliostats and fuel is calculated.

Keywords

solarized gas turbine; solar tower; energy analysis; exergy analysis; environmental analysis; Levelized Cost of Electricity

Acknowledgments

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A new form of decentralized energy: lessons from the WiseGRID project

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Abstract

The purpose of this article is to provide an analysis of smart grids in the European Union (EU) as a way forward to reach de-centralized sustainable energy. It does so by assessing the energy security, regulatory, as well as social and ethical aspects of smart grids in the EU. The article represents a significant milestone in the up-scaling of the various aspects of smart-grid technology across the EU. This article deals with smart-grids deployment and their impact on energy security with a view to a stronger role of prosumers in the energy market. It also analyzes smart grids regulation; specifically, it examines the existing legal frameworks that impact smart grids in the EU. It outlines existing EU Directives and assesses the level of implementation of these Directives in various EU Member States. The article also assesses the extent to which the existing legal frameworks facilitate the development of smart grids and proposes areas of further regulatory consideration. The article then explores the social and ethical dimension of smart grids in the context of the collaborative economy, the circular economy, and digital technology, including cyber-security and data-management issues.

Keywords

energy decentralization; energy democratization; digitalization; decarbonization; de-regulation

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RESRB2019.0046

Low carbon Arctic smart community: the ultimate case study of an Arctic renewable energy perspective

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Abstract

Challenges have always existed in the Arctic fossil fuels exploitation ventures, generally linked to technical, environmental, economic, commercial and social aspects of production and use. Remote locations with sensitive environments, expensive extractive operations and impacts on Arctic communities are a few examples of these challenges. However, the Arctic nations have taken an invaluable opportunity to make effective changes in how the Arctic energy system is viewed by creating new energy models based on Renewable Energy resources (solar, wind, geothermal, tidal, etc). This great potential for a sustainable prosperity project of co- management was initially debated in 'Renewable Energy for the Arctic: New Perspectives' (Arruda, G.M. (2018) Renewable Energy for the Arctic: New Perspectives. Routledge, Oxford) and, in 2019, it is undeniable that despite the relevant installation of pilot projects there are still many communities in the Arctic experiencing high levels of energy poverty, social sensitivity, and environmental fragility. The technological and innovative energy approaches from the pioneering Alaskan Renewable Energy smart grids not only have shifted energy production and use from fossil fuels to a more sustainable path, but also have provided a new horizon of durable energy access to Alaskan remote communities. The Alaskan smart-grid projects reflect a great effort of local experts and a significant contribution to manage local and regional energy demand flows, optimize energy use, minimize fossil fuels impacts from diesel generators and create a low carbon Arctic smart community based on a decentralized-type of renewable energy system relying on advanced storage and metering systems. The stabilization, efficiency and integration of the Alaskan Renewable Energy smart-grids offer new challenges and opportunities for the years ahead and is the ultimate case study of socio- technical energy systems co-evolving with smart technological solutions, co-management approaches, contemporary energy policies with a perspective of application at global scale.

Keywords

renewable energy; smart-grids; environmental impacts; socio-technical energy systems; smart communities

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Feedback from conference participants

It was a real pleasure participating in this conference. The quality of the programme was very good and I enjoyed all keynote and plenaries in which I was present.

A. A., University, City, Country

Author index

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