13TH CONFERENCE ON
SUSTAINABLE DEVELOPMENT
OF ENERGY, WATER AND
ENVIRONMENT SYSTEMS

BOOK OF ABSTRACTS

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Conference Venue: Palermo

„Palermo was lovely. The most beautifully situated town in the world - it dreams away its life in the Conca d'Oro, the exquisite valley that lies between two seas. The lemon groves and the orange gardens were entirely perfect.“ – Oscar Wilde

Palermo, the capital city of Sicily, is located in the heart of the Mediterranean sea. Built and grown over the course of centuries, Palermo conveys a range of diverse cultures and traditions, from the Fenicians to the Romans, Arabs, Normans and Spanish-French people, until the recent unification within the Italian kingdom. It has preserved much of the priceless heritage handed down by the peoples who populated it. They left indelible traces not only in its artistic patrimony but in its very vital rhythm of life. In the historical center and at walking distance between them, you will find several famous cultural and architectural attractions of the city.

Mondello

Mondello is the elegant seaside borough of Palermo (at a 12 km distance from the city center), famous for tropical colors beach, villas in liberty style and for sport activities (windsurf, sailing, beach volley). Mondello beach is a true paradise for those who love the sun, the sea and the sunbathing. White and fine sand beaches and emerald-green sea are its strong points, besides the beautiful and charming landscape. It is located between two promontories, Monte Gallo and Monte Pellegrino, this last been depicted by J.W. Goethe as "the most beautiful promontory in the world". Here you can enjoy a walk, eating ice-creams or exploiting the wide choice of sea food in the many trattoria around the central square of the small village.

Scope and Objectives

The 13th Conference on Sustainable Development of Energy, Water and Environment Systems - SDEWES Conference, to be held in Palermo in 2018, is dedicated to the improvement and dissemination of knowledge on methods, policies and technologies for increasing the sustainability of development by de-coupling growth from natural resources and replacing them with knowledge-based economy, taking into account its economic, environmental and social pillars.

The Conference will also be the first one to be held on an island, coinciding with the start of "Greening the Islands" initiative.

"History teaches us that men and nations behave wisely once they have exhausted all other alternatives"

Abba Eban

One of the main issues of the coming decades is to improve efficiencies by integrating various life-supporting systems, using excess from one, as resource in other, and in the exact moment when it is beneficial to all, integrating electricity, heating, cooling, transport, water, buildings, waste, wastewater, industry, forestry and agriculture systems. Sustainability being also a perfect field for interdisciplinary and multi-cultural evaluation of complex system, the SDEWES Conference has become a significant venue for researchers in those areas to meet, and originate, discuss, share, and disseminate new ideas within:

- Sustainability comparisons and measurements (metrics and indices; multi-criteria analysis; external costs; exergy analysis; footprint methods; emergy; life cycle analysis)
- Green economy and better governance (circular economy; low carbon development/economy; resource efficiency; water reuse; jobs and regional development; macroeconomic analysis; financial and regulatory mechanisms; models and tools; rebound effect; energy economics; environmental economics; development economics; sustainability economics)
- Smart energy systems (markets; demand response; integration of power, heating/cooling, transport, water and waste sectors; smart grids; dynamic electricity pricing, microgrids)
- Energy policy (security of supply; climate change mitigation; energy transition; renewable energy support schemes; energy efficiency policy; employment creation; carbon pricing; markets; fossil fuel subsidies)
- Smart transport systems and policy (fuel/carbon economy; transport electrification; congestion and road pricing; multimodal management; alternative fuels; social aspects; autonomous mobility; railways; shipping; aviation)
- Water-energy nexus (water management; water system analysis; water pricing; water desalination; hydro energy; water-renewables integration, water resources; river basin management; arid areas)

"You never change things by fighting the existing reality. To change something, build a new model that makes the existing model obsolete."

Buckminster Fuller, philosopher, futurist and global thinker (1895 - 1983)

- Environmental policy and management (waste management; wastewater management; climate change mitigation; climate change adaptation; air pollution policy; water pollution policy; land management; biomass management; rewilding; social aspects; strategic environmental impact assessment, environment and corporate social responsibility, quality management systems; environment management systems; eco management and audit schemes; occupational health and safety assessment systems; hazard analysis and critical control point; integrated management systems)
- Agricultural policy (energy and water use in agriculture and food processing; food vs. biofuels; sustainability of biofuels production)
- Social acceptance (reform; NIMBY; nuclear; wind; biofuels; hydrogen; hidden and special interests; cost based pricing; inclusion; fossil fuel subsidy; green economy and employment; gender issues; energy poverty; energy affordability)
- Sustainable resilience of systems (resilience of energy systems; resilience of water systems; resilience of environmental systems; resilience of agricultural systems; resilience of social systems; resilience of engineering systems)
- Sustainable tourism (green hotels; certification)
- Urbanism (smart cities; urban planning; zoning; transport; zero energy buildings/districts; sustainable energy action plans; district heating/cooling)
- Regional planning and cooperation (sustainable islands; regions and cities; 100% renewable regions)
- Research, innovation and development (industry-academia partnership; quadruple helix; knowledge based society; knowledge management; learning curve; technology foresight; science diplomacy)
- Education in sustainable development (governance; environmental awareness; higher education; engineering education)
- Energy system analysis (energy planning; power system planning; smart energy systems; smart energy networks; natural gas system planning; 100% renewable energy systems; high penetration of renewables; island energy systems; development of energy planning tools; internalizing environmental externalities; electrification of transport; storage vs. grids vs. demand management; long term demand planning; integration of power and district heating systems; integration of power and water systems; integration of power and transport systems; power to gas)
- Transport management (transport system analysis, dynamic road pricing; electrification of transport)
- Renewable energy resources (biomass; hydro; wind; solar; geothermal; wave and ocean; technical and economic potentials; barriers; cost and benefits; integration)
- Primary energy resources (oil peaking; gas; coal peaking; nuclear fuels)
- Renewable electricity generation systems (biomass; hydro; wind; offshore wind; high altitude wind; photovoltaic; concentrated solar thermal power; geothermal; wave; tide; ocean thermal)
- Thermal power plants (clean coal; combined cycles; advanced cycles; flexible operation and cycling; carbon capture and storage/sequestration/reuse; nuclear)
- District heating and/or cooling in smart energy systems (integration of renewable heat; cogeneration; industrial waste/excess heat; waste to energy and CHP; power to heat; electric boilers; heat pumps; integration of CHP with district heating and electricity markets; heat maps; distribution)

- Nano and micro technologies and science for sustainable development of energy, water, and environment systems
- Advanced sustainable energy conversion systems (fuel cells; thermoelectric; thermionic; organic; ORC; waste/excess heat recycling; thermoacoustic; piezoelectric)
- Renewable heat systems (biomass; biofuels; biogas; solar; geothermal)
- Biofuels and biorefineries (biodiesel; bioethanol; biogas; second and third generation biofuels; waste to biofuels; algae; anaerobic digestion; BTL; biorefineries; alternative fuel vehicles; infrastructure; sustainability assessment; pyrolysis; torrefaction; coproduction)

"If there are to be problems, may they come during my life-time so that I can resolve them and give my children the chance of a good life."

Kenyan proverb

- Alternative fuels (hydrogen; electro-fuels; power to gas; synthetic fuels; BTL; DME; CNG; resources; production; vehicles; infrastructure)
- Hybrid and electric vehicles (first generation hybrid; plug in hybrid; charging; batteries; infrastructure)
- Water treatment for drinking water
- Water desalination (distillation; reverse and forward osmosis; electrodialysis; energy recovery; discharge management)
- Waste and wastewater treatment and reuse (avoiding waste; composting; recycling; waste to energy; anaerobic digestion; gasification; mechanical biological treatment; mechanical heat treatment; plasma arc waste disposal; pyrolysis; RDF/SRF; combustion modelling)
- Modelling for pollution avoidance and energy efficiency (CFD models; air pollution spreading; water pollution spreading; heat and mass transfer modelling combustion modelling)
- Cogeneration, trigeneration, polygeneration (heat/cold and power; water and power; biofuels and power; transport and energy; food and energy; applications and operation strategies)
- Storage (heat/cold storage; hydrogen storage; hydropower as storage; pump storage; compressed air storage; batteries; water storage; biofuels storage; storage optimisation modelling; financial support mechanisms; power market arbitrage)
- Electricity transmission and distribution (grid extension and robustness; long distance transmission; power quality)
- Gas security of supply (diversification; shale gas; extension of transmission pipelines; LNG; Southern Corridor)
- Energy and water efficiency in industry and mining (cement and lime; construction materials; glass; pulp and paper; food industry; metallurgy; chemical industry; process optimisation; kilns; boilers; heat exchange networks; pinch analysis; exergy and exergoeconomic analysis; energy audits; water use and waste minimisation; eco-innovation; total site integration; life cycle assessment; eco-design and eco-labelling; product cycle assessment; cleaner production, environmental impact assessment)
- Energy efficient appliances (smart appliances; labelling and standards; user behaviour)
- Buildings (nearly zero energy buildings; passive buildings; smart buildings; smart metering; ICT; load and demand side management; green buildings; building codes and standards; buildings certification; HVAC; insulation; renewables integration; heat pumps; storage; sustainable architecture)

- Energy markets (market/price coupling; liberalisation/deregulation; modelling; demand response; role of district heating; desalination and water pumping; storage; retail markets; grid parity; net metering)
- Emission markets (emission trading system; cap and trade; transport participation)
- Political aspects of sustainable development (long term planning; sustainable development goals; the role of political leaders and of voters; international conflict vs. sustainable development; security and sustainability; resource and political security)

"Then I say the Earth belongs to each generation during its course, fully and in its right no generation can contract debts greater than may be paid during the course of its existence"

Thomas Jefferson, September 6, 1789

Preface

The objective of the series of conferences on Sustainable Development of Energy, Water and Environment Systems (SDEWES) is toprovide a forum for world-wide specialists and those interested in learning about the sustainability of development, to present research progress and to discuss the state of the art, the future directions and priorities in the various areas of sustainable development. This includes the improvement and dissemination of knowledge on methods, policies and technologies for increasing the sustainability of development, taking into account its economic, environmental and social pillars, as well as methods for assessing and measuring sustainability of development, regarding energy, transport, agriculture, water and environment systems and their many combinations. The reason for the forum having such a wide scope is due to the need for holistic integrated solutions encompassing several or all sectors.

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BOOK OF ABSTRACTS

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Plenary lectures

SDEWES2018.0474

Sustainable Energy: a Key to the Sustainability of Environmental Systems

M. Rosen*

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Abstract

Sustainability is a critically important goal for human activity and development. Sustainable energy is of great importance to any plans for overall sustainability, and a key to the sustainability of environmental systems. This is particularly important given the pervasiveness of energy use, its importance in economic development and living standards, and the significant impacts that energy processes and systems have on the environment. Many factors that need to be considered and appropriately addressed in moving towards energy sustainability are examined in this talk. These include appropriate selection of energy resources bearing in mind sustainability criteria, facilitation of the use of sustainable energy resources, enhancement of the efficiency of energy-related processes, and a holistic adoption of environmental stewardship in energy activities. In addition, other key sustainability measures are addressed, such as economics, equity, land use, lifestyle, sociopolitical factors and population. Conclusions are provided related both on options for energy sustainability and on means to enhance the sustainability of environmental systems.

SDEWES2018.0513

Consumer Ownership,natural Monopolies and Green Energy Transition

F. Hvelplund*

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Abstract

In the Danish transition to 100% renewable energy, public regulation has to deal both with short term goals such as cost and price efficiency, security of supply etc., and the long term green transition from sectorised fossil fuel systems to integrated smart energy systems based on energy conservation and renewable energy. Making this combination of short and long term regulation efficient requires a multifacetted regulation where both economic incentives and organizational changes are needed. In this paper we will focus upon the combination of economic incentives and a revitalized consumer ownership model.

On both a short and long term basis consumer ownership furthers a drive for both low costs and low prices, and thus is **the** price efficient organisation for natural monopolies. In the Danish municipality and consumer owned electricity distribution system this has resulted in electricity prices that are 25% lower than average EU prices, despite that Danish prices includes subsidies to the green transition.

Going from a regulation of fossil fuel sector based systems to smart energy systems also requires an active public regulation in combination consumer participation in order to reduce the transaction costs linked to the many coordination tasks in integrated smart energy systems. Furthermore a well functioning consumer ownership organisation activates the consumers in such a way that they enter a learning process that make them both generate new ideas for their company and in a qualified way supports a green political discourse that also inspires the central policy makers and planners.

The conclusion in the paper is that an efficient and trransparent public regulation in combination with a welfunctioning consumer ownership organisation is a necessary base that leads to both prise efficiency and a learning process that supplies knowledge to a green energy transition process. And illustrated by Danish cases that new models for revitalizing consumer ownership can be established amongst other by means of the new tools of online voting and communcation.

SDEWES2018.0512

Water Minimisation via Integrated Planning and Management of Water Supply and Demand

S.R. Wan Alwi*, Z. Abdul Manan

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Abstract

Clean water supply is becoming more scarce nowadays due to rising demand caused by growing population, climate change and widespread pollution. Providing clean water supply by using technologies such as desalination or membrane treatment are energy and cost intensive. Options such as rainwater harvesting also have limitations in terms of inconsistent supply, apart from requirement of water treatment. Water minimisation can be effectively achieved when minimisation options such as demand elimination and reduction are prioritised. This is followed by reuse/recycling, outsourcing and regeneration of water and wastewater sources, in line with the Water Management Hierarchy. Grey water reuse has long been introduced, while systematic techniques to maximise water recovery within an industry has been established via methods such as Water Pinch Analysis or mathematical modelling. In this lecture, the concept of exchanging water on larger scales across industrial sites are introduced to efficiently manage water demand and address water supply issues. The mechanism, economics, opportunities as well as challenges are also discussed.

Special session: Energy, Water and Resource Efficiency for Sustainable Future: Knowledge Development and Transfer

This session provides a platform for development of modern technologies for energy and water efficiency and for exchanging ideas in the field, supplemented by key contributions geared towards more efficient knowledge management. They include, beside the others, the Process Integration and optimisation methodologies and their application to improving the energy and water efficiency of mainly industrial but also nonindustrial users. An additional aim is to evaluate how these methodologies can be adapted to include the integration of waste and renewable energy sources for energy conversion and water supply/purification. The session is outlining the field of energy and water efficiency, including its scope, actors, and main features. The deals with energy and water saving techniques. An increasingly prominent issue is assessing and minimizing emissions and the the environmental footprints: carbon and water footprints. The carbon footprint (CFP) is defined by the U.K. Parliamentary Office for Science and Technology as the total amount of CO2 and the other greenhouse gases emitted over the full life cycle of a process or product. IN a similar way the water footprint embodies the various water quantities used for the manufacturing and delivery of a product. For energy supply, there have been numerous studies that emphasize the “carbon neutrality” of renewable sources of energy. However, even renewable energy sources make some contribution to the overall carbon footprint, and assessment studies frequently do not account for this. The carbon footprint should also be incorporated into any product life-cycle assessment (LCA).

Session organizers:

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Jiří Jaromír Klemeš - Head of “Sustainable Process Integration Laboratory – SPIL”, NETME Centre, Faculty of Mechanical Engineering, Brno University of Technology - VUT Brno, Czech Republic and Emeritus Professor at “Centre for Process Systems Engineering and Sustainability”, Pázmány Péter Catholic University, Budapest, Hungary. Previously the Project Director, Senior Project Officer and Hon Reader at Department of Process Integration at UMIST, The University of Manchester and University of Edinburgh, UK. Founder and a long term Head of the Centre for Process Integration and Intensification – CPI2, University of Pannonia, Veszprém, Hungary. Awarded by the EC with Marie Curies Chair of Excellence (EXC). Track record of managing and coordinating 91 major EC, NATO and UK Know-How projects. Research funding attracted over 21 M€. Co-Editor-in-Chief of Journal of Cleaner Production. The founder and President for 20 y of PRES (Process Integration for Energy Saving and Pollution Reduction) conferences. Chairperson of CAPE Working Party of EFCE, a member of WP on Process Intensification and of the EFCE Sustainability platform. He authored and co-authored nearly 400 papers, h-index reaching 42. A number of books published by Elsevier, Woodhead, McGraw-Hill; Ashgate Publishing Cambridge; Springer; WILEY-VCH; Taylor & Francis). Several times Distinguished Visiting Professor at Universiti Teknologi Malaysia and University Technology Petronas, Malayisa; Xi’an Jiaotong University; South China University of Technology, Guangzhou and Tianjin University in China; University of Maribor, Slovenia; Brno University of Technology and the Russian Mendeleev University of Chemical Technology, Moscow. Doctor Honoris Causa of Kharkiv National University “Kharkiv Polytechnic Institute” in Ukraine, the University of Maribor in Slovenia, University POLITEHNICA Bucharest, Romania. “Honorary Doctor of Engineering Universiti Teknologi Malaysia”. Awarded with “Honorary Membership of Czech Society of Chemical Engineering", "European Federation of Chemical Engineering (EFCE) Life-Time Achievements Award" and "Pro Universitaire Pannonica" Gold Medal.

Invited submissions

SDEWES2018.0037

Designing for the Batch Water Network with Flexible Production Scheduling Framework

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Abstract

Batch processes are mostly suited to producing low volume products and are capable of accommodating the rapid changes of the market. For a given batch plant, if one of its outdated products is replaced by a new product, the production scheduling will change accordingly without necessarily changing the structure of the plant. Although many papers have addressed simultaneous optimization of water network and production scheduling for batch processes based on mathematical programming, the insight-based methods are rare. This work proposes a three-step method to design batch water networks with flexible production scheduling. Because it is based on the conventional pinch analysis, it provides physical insights for the designer about the water utilization in the processes, rather than the final results obtained by mathematical methods. The proposed methodology is illustrated as follows. Firstly, pinch analysis proposed for continuous processes is used to determine the target for freshwater consumption and define the pinch point and pinch-causing sources. The pinch point divides the process into two parts, i.e. below or above pinch point. Secondly, in each area, sub-networks are then configured based on the insight of pinch analysis. It can determine the reuse of internal sources in each area and the allocation of water from pinch-causing sources to below and above pinch point areas. Thirdly, we can determine which pinch-causing source is supplied to the specific water sink in each area and check the feasibility of time constraints. If the obtained water network is feasible under the time constraint, the final batch water network is determined. Two examples from literature are considered to demonstrate the feasibility of the proposed method. In the first example, a water reuse/recycle scenario is considered. Results indicate a 50% reduction in freshwater consumption compared to the base case without water integration. In the second example, a batch plant with reuse/recycle and regeneration scenario is taken into account. Results show that freshwater consumption of batch processes with flexible product scheduling could be further reduced by 15.7% compared with the scenario of predefined production schedule. Furthermore, the makespan could be reduced.

SDEWES2018.0043

Water, Energy and Shale Gas Optimization: from Production to Transmission

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Abstract

This work presents a mathematical framework for a comprehensive assessment of shale gas exploration using continuous time formulation. The study simultaneously integrates water, energy and shale gas optimization. The shale gas optimization entails the production of shale gas at shale sites, processing, distribution, electricity generation at power plants and transmission to the end users .The aforementioned processes are integrated simultaneously because they all have economic impact on the overall system. Wastewater treatment or regeneration is achieved using membrane distillation (MD), whereby the treated water can be reused at the next fracturing operation. Since membrane distillation is an energy intensive process, a detailed design model is developed and incorporated within the network superstructure in order to allow for simultaneous optimisation of water, operation, capital cost as well as energy used by the water regeneration facility. The study considers natural gas as fuel for commercial, industrial and residential customers, as well as fuel for electric power generation, with the goal of maximizing the overall profit. The developed formulation yields a large-scale mixed integer nonlinear programming (MINLP) mathematical model. The resultant model is applied in a case study, which is a representative of Marcellus shale play to demonstrate its applicability. The application of the model results in 22.4 % reduction in freshwater consumption, 23.2 % savings in the total cost of freshwater and 12.7 % reduction in the energy required by the regenerator.

SDEWES2018.0126

Overview of the Water Desalination in China: Development, Energy Demand and Emissions

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Abstract

Resource supplies and allocations highly interact in terms of energy demand, which also lead to the complex nexus between energy and other specific resources. Water-energy nexus has become one of the most focused interrelationships due to its importance and impact on the environment. Water desalination is one of the solutions for water scarcity in many cities in China, and it has been considered as a technique with high water supplying potential. However, the implementation of new solutions also increases the cost (e.g. economic and energy cost) of getting clean water, and the water-energy nexus of water desalination has not been discussed properly. The aim of this work is to 1) provide a brief summary of the implementation of water desalination in China, including the capacity, distribution, as well as economic and environmental cost; 2) discuss the energy demand of the water desalination implementations in China; 3) provide remarks for the further studies of the water-energy nexus of water desalination.

SDEWES2018.0145

Water Footprint and Water Quality Evaluation Accounting for Multiple Contaminants

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Abstract

Water shortage and pollution issues have become severe global issues. There were still 2.1 billion people worldwide without access to clean drinking water in 2015 (WHO and UNICEF, 2017). These water issues have been frequently discussed in scientific research. For example, water footprint assessment framework (Hoekstra et al., 2003) has been developed and widely used in water use assessment at various scales – from individual to organisational and national levels (ISO, 2014). This framework is centered around the volumetric amount of water use. As a result, the provided water footprint metrics do not capture the water quality impacts (Wichelns, 2017). Some indicators are developed to determine the water quality condition of a specific river, river basin, or a region.

Essentially, the evaluation of volumetric water consumption and water quality are not performed jointly. Besides, the anthropogenic changes in water quality or water availability are not yet well researched. The water shortage globally is not only caused by direct water shortage, but also the water quality degradation. Frequently, there is a shortage of clean water instead of general water shortage.

There is a need to investigate the anthropogenic impact on water quality changes. Water quality degradation is a complex issue due to the instability of water and the multiple pollutants in the water. The aim of this study is to develop indicators integrating water quantity and quality. These should account for the presence of multiple contaminants in water and allow evaluation of networks involving water reuse, recycling, and cleaning operations. Based on this conceptual framework, the determination of water availability footprint is demonstrated.

SDEWES2018.0473

Simultaneous Retrofit and Process Changes of Heat Exchanger Networks

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Abstract

State-of-the-art heat exchanger network (HEN) retrofit methodologies based on Pinch Analysis have largely focused on improvement of HEN, and much less on exploring options for process changes (or process modifications) to enhance energy efficiency of process systems. Pinch-based retrofit methodologies typically employ Composite Curves (CC) and Grand Composite Curve (GCC) to guide process changes. As CC and GCC are representations of composite process streams, the specific individual process streams to undergo process changes may not be readily identified from CC and GCC. This work extends the use of individual stream temperature versus enthalpy plot (STEP) for the simultaneous retrofit and identification of process changes options to improve heat recovery and energy efficiency of processes. Application of the method on an illustrative case study shows that STEP enables a designer to graphically pinpoint the exact individual hot and cold process streams to undergo process changes, and to determine the magnitude of process changes needed to be performed. Results show that the procedure further reduces the process cooling requirement by 3.45% without any additional capital investment, on top of performing HEN retrofit.

SDEWES2018.0484

Temperature Disturbance Management in Heat Exchanger Network for Maximum Energy Recovery

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Abstract

Heat exchanger network (HEN) synthesis is a vital part in the process industries as it enables the energy to be well utilised [1]. The dependence of fosssil fuels as a primary energy source makes the environment more vulnerable to the negative impacts. A major way to improve the environmental and economical impacts of the production plants is through an efficient HEN. İn plant industries, several parameters of HEN design are possible to fluctuate from the nominal conditions such as the temperatures and flowrates of the process due to the significant changes in the environment of the plant [2]. Therefore, it is required to design HEN that can feasibly operate over a range of the fluctuate value and this leads to a flexible HEN design. The network configuration associated with the disturbance propagation throughout the network may influence the process behaviour as well as limit the process to be controlled and operated [3]. Linnhoff and Hindmarsh [13] introduced Pinch Design Method (PDM) which have rules in the selection of streams matching, the sequences and duty of heat exchanger in order for designing the HEN. However, it only aims to maximise the energy recovery considering the trade-off between capital and operating costs. Furthermore, the conventional PDM also performed under the assumptions of fixed operating paramaters at nominal conditions. Therefore, the motivation of this paper is to design a HEN which is feasible over a range of fluctuating supply temperatures and heat capacity flowrates. Some new heuristics in Pinch Analysis is introduced for designing a flexible HEN. With respect to HEN synthesis, this proposed approach follows the heuristic rules by Linnhoff and Hindmarsh [12] in streams matching and designing an optimum HEN configuration with maximum heat recovery optimisation. Through this heuristics, several HEN design can be formed. The various possible design of HEN which contributes towards flexibility are investigated, and heuristics are proposed. This methodology allows the designers to choose the most suitable design target either for the purpose of improving network's energy recovery and/or short disturbances propagations. The new heuristics proposed are then tested by using illustrative case study to show its practicality.

SDEWES2018.0008

Autocorrelation Robustness of Factorial Designs and Gams in Studying the Effects of Process Variables in a Dual-Objective Adsorption System

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Abstract

The performance of factorial designs is still limited due to some uncertainties that usually intensify process complexities, hence, the need for inter-platform autocorrelation analyses. The main purpose of this study is to compare the variable effects autocorrelation capabilities of factorial designs and General Algebraic Modeling System (GAMS) towards making a steadier trade-off decision on appropriate choice of variable(s) for the respective objective function(s). A full-factorial dual-objective adsorption process model is validated with GAMS with regions of germane process variables for process analyses under uncertainty. The variables are adsorbent dosage, mixing speed and contact time; while objective functions are the silica and dissolved solids. Results of the factorial design unveil the process variable interactive effects and their curvatures on the responses, which are facilitative in divulging the expedient information concealed underneath the variable interactions that affect the system performance. In order to provide the accurate conclusions, the individual and combined models were implemented in GAMS and solved with the trio of BARON, CPLEX and IPOPT solvers. The analysis is conducted and the conclusions are drawn based on the marginal values, intensity of variable significance, and percentage errors of the results obtained from both platforms. It is revealed that the dosage as a variable had the highest effect on the whole process based on its significant p-value of at least 0.0005 as suggested by the analysis of variance (ANOVA) from the factorial design and highly significant marginal value (the true magnitude effect on the objective function subject to a slight change in the process variable) from GAMS. This variable contributed the most effect that push towards obtaining the minimum silica and TDS contents of 13 mg/L and 814 mg/L; and 13.6 mg/L and 815 mg/L from factorial and GAMS platforms, respectively. This indicates a concurrence between the results of the two platforms with percentage errors of 4.4 % and 0.2 % for silica and TDS, respectively. The effects of the mixing speed and contact time are negligible and the regression models for silica and TDS generated coefficients of determination (R^2) of 0.9994 and 0.9999, respectively. These results can provide more reliable variable interactive effects and will surely assist the decision makers in generating firm decision alternatives in related sorption processes.

SDEWES2018.0023

Value Chain Mapping of the Water and Sewage Industries Towards Sustainability Initiative

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Abstract

Inaccessible hygiene water sources and sanitation are one of the sustainability issues that need to be solved. One attempt to solve this problem is to change the conventional systems used in the water and sewage industry towards the sustainable water and sewage management. To transform the system, the companies initially need to map their business value chain. This study aims to observe the value chain mapping process in the water and waste industry. Qualitative analysis includes reviews of related literature and case studies used to conduct this research. Water and Waste Khuzestan Company in Iran has been selected as a case study. The results of the analysis present the main processes of the business value chain, key actors involved in the value chain, the relationship between actors, the capacity of the products and services, and identification of problems and potential solutions.

SDEWES2018.0045

The Greenhouse Gas Emission of Different Waste Treatment Alternatives for Municipal Solid Waste

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Abstract

This study assesses the Greenhouse gas (GHG) emissions of different waste treatments for municipal solid waste (MSW). The included options are composting, waste to energy (incineration and anaerobic digestion), and to the landfill. The net emission (kg CO_{2eq}/t waste) is calculated by considering the emission emitted during the treatment process, avoided from the conventional generation of the products, and/or to the landfill. In general, this study proposes waste to energy is not a transition solution towards low carbon emission energy source. It is more appropriate to be classified as a waste treatment solution. This suggestion is based on the results of the CO_{2eq} emission from waste treatment process can only be compensated when the emission avoided from the landfill is considered. Composting is suggested to be a more environmentally options for MSW compared to the waste to energy. The interrelationship between the environmental performance of the waste to energy treatments and the power mix of a country is demonstrated in the second part of the study. Among the assessed countries (Paraguay, France, Finland, Denmark, Korea, Malaysia, China, Czech Republic), waste to energy is comparatively suitable in Malaysia, China and the Czech Republic. Incineration appears to be a slightly better option than anaerobic digestion. The energy conversion refers to this study is solely to electricity but not the heat. Further study is needed to overcome the limitations of this study.

SDEWES2018.0171

Multi-Criteria Optimisation of Municipal Solid Waste Management: Gis and P-Graph Approach

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Abstract

The municipalities are subject to increasing pressure for the sustainable municipal solid waste (MSW) management. It is a significant factor for improving the environmental quality and supporting the economic development. There are various types of MSW treatment technologies available reflecting different waste composition, scale, budget, resource constraints. However, the increasingly serious problem is how to manage the MSW from a comprehensively sustainable viewpoint, in order to optimise the Waste-to-Energy (WtE) efficiency, reduce the management cost and minimise the environmental impact. In this paper, the geographic information system (GIS) and P-graph are implemented as an integrated and a synthetical approach for MSW management. The GIS-based multiple criteria tools have been used for optimising the MSW treatment plants siting and minimising the transportation cost. An MSW treatment scenario based on the several technologies as anaerobic digestion (AD), incineration and landfilling was modelled in the P-graph Studio. The GIS and P-graph proved to be suitable partners for MSW management.

SDEWES2018.0184

Air Solar Collector with the Absorber Plate Containing Phase Change Material - Environmental Chamber Experiments and Computer Simulations

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Abstract

The influence of latent heat thermal energy storage integrated with the solar absorber plate was investigated by lab experiments and computer simulations. Two experimental air solar collectors were built for the investigations. One collector had the absorber plate made of sheet metal and the other had the absorber plate consisting of nine aluminium panels containing paraffin-based PCM. The collectors were positioned side by side in the chamber in order to perform the experiments under same conditions. The square-wave changes of the solar radiation intensity were used in the experiments. A good agreement was observed between the simulations and experimental data. The results showed that the outlet air temperature fluctuations (peak-to- peak amplitudes) were reduced from about 11 K in case of the solar collector with the metal sheet absorber to about 5 K in case of the collector with the absorber plate containing PCM under the tested conditions.

SDEWES2018.0222

Emission of Fine Combustion Particles from Micro-Scale Biomass Combustion in Oxygen Pure Atmosphere

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Abstract

This article extends earlier research of authors devoted to the experimental evaluation of ultra-fine particles production from laboratory combustion of beech wood samples. The paper presents a parametrical study carried out to assess the influence of the composition of the atmosphere and the temperature on the production of ultrafine particles during the micro-scale combustion process. The paper presents a laboratory procedure that combines the thermogravimetric analysis with detailed monitoring of the size distribution of fine particles produced. The study utilizes the laboratory scale identification of the formation and growth of fine particles during the temperature increase of beech wood samples. This paper compares particle emission produced by beech heartwood and beech bark. The size of emitted particles is very strongly influenced by the concentration of light volatiles released from the heated wood sample. From the experimental study, it is clear that decreasing oxygen content in the atmosphere generally results in higher particulate matter production.

This article extends earlier research of authors devoted to the experimental evaluation of ultra-fine particles production from laboratory combustion of beech wood samples. The paper presents a parametrical study carried out to assess the influence of the composition of the atmosphere and the temperature on the production of ultrafine particles during the micro-scale combustion process. The paper presents a laboratory procedure that combines the thermogravimetric analysis with detailed monitoring of the size distribution of fine particles produced. The study utilizes the laboratory scale identification of the formation and growth of fine particles during the temperature increase of beech wood samples. This paper compares particle emission produced by beech heartwood and beech bark. The size of emitted particles is very strongly influenced by the concentration of light volatiles released from the heated wood sample. From the experimental study, it is clear that decreasing oxygen content in the atmosphere generally results in higher particulate matter production.

Special session: Harnessing the resource potential of our seas in a sustainable manner

The sea represents a huge resource for renewable energy (Blue Energy - BE). BE is the energy which can be harnessed from the ocean or the marine wind and it is comprised of five main types according to the origin of the extracted power, namely marine (offshore) wind, surface waves, tides/currents, and thermal and salinity gradients. Although the growth of offshore renewable energy technologies has so far been relatively slow compared to those onshore, it is anticipated that in the future BE will substantially contribute to the energy demands of coastal and insular areas, at the same time protecting and conserving the marine environment.

The Blue Growth Strategy proposed by the Commission in 2014 emphasized that harnessing the economic potential of BE in a sustainable manner represents a key policy area for the EU, which requires the involvement of the widest possible range of stakeholders in order to optimize capacity building and to achieve the necessary critical mass. The BE sector was, in fact, indicated as one of five developing areas in the 'blue economy' that could drive the creation high-quality jobs and pave the way for a new breed of science-trained professionals, enhancing eco-efficient value creation all along the value and supply chain. Moreover, exploiting this indigenous resource would help reduce the EU dependence on fossil fuels for electricity generation, and enhance energy security. In particular, islands and remote coastal regions can especially benefit from BE development, as it would provide a viable alternative to expensive and heavily polluting fossil fuelled plants, and contribute to their energy self-sufficiency.

The exploitation of Blue Energy clearly opens new frontiers in the maritime sector, by creating synergies with long established traditional activities, yet opening the door to knowledge-driven innovation. It offers the opportunity to pool costs and boost several connected economic sectors. Some examples of synergic activities that are welcome in this Special Session include: BE Studies and technology design; Estimation of BE exploitable resources; Marine environment assessments for BE exploitation; Evaluation of synergies with aquaculture and/or fisheries; BE exploitation in the naval sector; Energy production from Algae; Design and management of multipurpose offshore platforms; Socio-economic assessment of BE exploitation.

Session organizers:

Dr. Hrvoje Mikulčić, University of Zagreb, Zagreb, Croatia

Dr. Gianmaria Sannino, ENEA, Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Rome, Italy

Hrvoje Mikulčić - HRVOJE MIKULČIĆ defended his PhD thesis in 2015 and works as a Postdoctoral researcher at the Department of Power Engineering, Energy and Environment, Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb. His main research area include numerical modelling of fluid flow, solid fuel combustion, endothermic calcination reaction, radiation modelling, pollutant formation, greenhouse gasses emissions analysis and accounting, and energy efficiency improvements in industry. Since 2009 he has been working on the research project "Numerical modelling of multiphase flow and combustion processes" financed by the Austrian Institute for internal combustion engines AVL List GmbH. He has also been working on the national scientific project: Smart energy storage for sustainable development of energy systems, financed by the Ministry of Science, Education and Sport of the Republic of Croatia. From 2016 he is a project manager of a European INTERREG MED project PELAGOS - Promoting innovative networks and clusters for marine renewable energy synergies in Mediterranean coasts and islands, responsible for the Croatian part of the project. He is an author of 43 scientific papers, of which 29 in scientific journals (SCI). His current Scopus h-index is 12. From 2014 he serves as a SDEWES Special Issue Guest Editor in the Journal of Cleaner Production (IF 2016 =5.715), Journal of Environmental Management (IF 2016 =4.010), and Clean Technologies and Environmental Policy journal (IF 2016 =3.331).

Gianmaria Sannino - Gianmaria Sannino, is Head of the Climate Modelling Laboratory and Impacts of ENEA since 2015. He has more than 20 years of experience in climate and ocean modelling. During the last 10 years he has worked in the field of regional climate modelling and ocean energy at ENEA. His current research activities are focused on the development and assessment of state-of–the- art regional climate models and their application to the renewable energy field. He was involved in many European and National projects on climate change, oceanography, and ocean energy. He is currently the PI the National Project “Evaluation of ocean energy potential for the Italian Seas”. He is the Italian representative at the Temporary Working Group "Ocean Energy " for the EU SET-Plan. He is in the scientific committee of the Joint Program “Ocean Energy” of the European Energy Research Alliance (EERA). He is also member of EuroGOOS, EERA (European Energy Research Alliance), and in the scientific committee for ECRA (European Climate Research Alliance) and Med-CORDEX (Mediterranean CORDEX initiative). He has published more than 50 papers in SCI journals and books, and contributed to several technical reports and presentations at international conferences.

Invited submissions

SDEWES2018.0266

The Influence of Climate Change on the Near Future Wave Energy Resources in the Black Sea Basin

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Abstract

The increasing investments in the renewable energy require also an estimation of the future evolution of these resources. Climate change represents a challenge for the ocean energy sector, where the renewable energy extracted from waves and wind has an important role. The main objective of the proposed work is to evaluate the near future wave power resources (2021-2050) in the Black Sea basin, based on the results obtained with a wave modelling system forced with wind fields provided by a Regional Climate Model (RCM). In the framework of the EURO-CORDEX experiment these wind fields with a resolution of 0.11 degrees (EUR-11, ~12.5km) cover the entire European domain, including also the basin of the Black Sea. Two wind fields are considered in the wave model simulations, according to two Representative Concentration Pathways (RCPs) emission scenarios, namely RCP4.5 and RCP8.5. First scenario considers midrange mitigation emissions, while the second is a more aggressive scenario.

A model based on the spectrum concept is considered for the wave energy predictions. This is SWAN (Simulating Waves Nearshore), which has been implemented over the Black Sea basin and extended validated against both in situ and remotely sensed measurements, so that it results can be considered accurate and reliable.

In order to estimate the influence of the climate change on the wave energy resources in the Black Sea basin, the results obtained in the near future 30-year period (covering the early 21st century) are compared with historical conditions simulated also for a time-slice of 30 year (1976-2005). The historical wave energy resources are obtained using historical RCM wind fields to force the wave model. Statistical methods for data analysis are used, in order to estimate the variability of the resources or some trends.

SDEWES2018.0359

Multidisciplinary Research of the Adriatic Sea Carried During the Project Core in Croatia and Montenegro and its Results Including the Highest In-Situ Measured Wind-Induced Sea Surface Wave in Southern Adriatic Till March 2018

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Abstract

Partner institutions Hydrographic Institute of the Republic of Croatia (HHI), Institute for Marine and Coastal Research in Dubrovnik (IMP), Institute of Hydrometeorology and Seismology of Montenegro (IHMS), and Public Enterprise for Coastal Zone Management (JPMD) successfully managed the 23-month long EU/IPA Project CoRE (Cross border joint research and awareness raising action in detecting environmental conditions. Establishing higher safety and protection measures of Maritime domain parts of Croatia and Montenegro) which started in January 2016. During the project thorough multidisciplinary (bathymetry, hydrography, physical, biological, geological and chemical oceanography) research was carried out in 5 geographic areas - Croatia (Dubrovnik and Neretva area) and Montenegro (Sutomore, Mogren and Ada Bojana area). The results of comprised measurements and surveys, including sea currents, sea surface wind induced waves, thermohaline properties, acidity, nutrients, oxygen saturation, coastal flora and vegetation, benthic biocenosis, sediment granulometry analysis and sea bottom bathymetry description of the area are presented in this article. Interestingly, amongst the in-situ data measured near the islet of St. Andrija (near Dubrovnik) is also the largest reported in-situ measured wind-induced sea surface wave height in Southern Adriatic ever. The results of this project describe and determine the conditions and the current environmental status at the sites (including species under various protection categories). They can be used as valuable parts of the (locally possible zero-state) description of the ecosystem and are considered as important information for the safety of all maritime traffic in the area. As such, following the appropriate IHO standards and regulations, the gathered data are included in the official nautical publications.

SDEWES2018.0382

Open Sea Facility Design and Testing for Wave Energy Converters

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Abstract

The paper describes the activities that has led to the installation of a unique facility located in La Spezia, Italy, for testing wave energy converters. This consists of an open-sea wave tank with the possibility of physical generation of different wave sea states in deep water conditions and real environment. This wave tank facility can produce waves up to 0,7m in height and 4s in period, having an overall wave front of 5m.

The system consists in a flap-type wavemaker characterized by a fixed structure and a mobile one. This fact facilitates maintenances activities and plant dismantling process of the submerged components. The wavemaker is composed by 5 modules, identical for dimensions, characterized by 1m width each. The height of the modules, namely a flat bulkhead, is about 4m, and has been designed as a cantilever element: this allow the complete removal of each module from water. The wavemaker is driven by a pump-motor unit of about 40kW, the oil under pressure is then responsible of the activation of 5 double-effect, double-rod, pistons. The linear postion of each piston is monitored thanks to a dedicated real time laser sensor.

The paper encompasses the design of the facility, the construction features, and the commissioning tests. The facility is now ready to host different experimental campaigns in real sea conditions, the first one targeting the latest prototype of Seaspoon wave energy converter (1kW mechanical power), for off-shore power supply applications.

SDEWES2018.0419

Offshore Platforms Reuse in Wave and Wind Energy Production for the North Adriatic Sea

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Abstract

This paper primarily focuses on the potentiality to produce clean energy on the locations of a Croatian-Italian joint venture offshore gas platforms. Recently a Joint declaration of Italy and Croatia asserted the need to develop integrated systems and monitoring methodologies in relation to the offshore installations for the extraction of natural gas in the Adriatic Sea, facilitating reuse of the offshore platforms that have finished or are ending the operational life of the geological reservoir.

In the context of green decommissioning, interest is growing in the concept of repurposing offshore gas assets to support development of renewable power in the transition to a sustainable energy future which does not harm the marine environment.

A first step to develop offshore sea energy exploitation is the knowledge of the available natural resources i.e. wind and wave energy potentials.

To date an extensive and accurate estimate of the offshore wave and wind energy for the Croatian part of the Adriatic Sea is not available.

The objectives of this work are: (i) to assess the wave and offshore wind energy potential around the platforms, as a potential measurement and verification points; and (ii) to investigate and determine the potential sites and areas best suited for offshore renewable energy sources (RES) exploitation in the North Adriatic Sea, considering the renewable energy resource assessment available.

Hind casted wave and offshore wind data obtained with numerical models are used implementing a pioneering information crucial for launching offshore wave and wind energy exploitation in the Adriatic Sea.

Such preliminary information on available offshore RES resources will enable more thorough and precise investigation of wave and wind energy potential on the north Adriatic Sea reducing costs by exploiting existing offshore platforms for measurements and providing unambiguous information for offshore wave and wind farms deployment in the Adriatic, as one of the next steps in RES development in European energy policy by 2030 and beyond.

SDEWES2018.0422

Experimental Investigation on the Dynamics of a Floating Wec with PTO Phase Control

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Abstract

INTRODUCTION AND AIMS: The device under development is a floating Wave Energy Converter (WEC) of the Activated Body type. The dynamics (shape and amplitude) of the buoy oscillations can be modified acting on both the gain and the delay of the reactive force applied by the Power Take Off (PTO).

It is in theory not sufficient to investigate the power production of the WEC simulating for instance only the PTO gain (or load). This is well known (Sheng et al., 2015; Korde and Ringwood, 2016) but this aspect is still regularly overlooked by most experimental hydraulic studies. The aim of this paper is to experimentally investigate how a modification of the electrical impedance of the PTO affects the hydrodynamic response of the WEC in terms of floating body movements and consequently on the overall efficiency.

METHODS: A team of electrical and hydraulic researchers will jointly investigate a WEC device in the laboratories of Padova University. To modify the phase control, one approach involves a real PTO (even if subject to small waves) varying the phase (capacitance) and gain (resistance) of the circuit harvesting the energy. In a second approach, the floating body movements are directly restrained by a reactive force controlled by a micro-computer in real time.

EXPECTED RESULTS: The relevance of the obtained results are expected to pose a warning on the interpretation of the existing experimental investigations that model the PTO systems through mere resistive devices. Therefore, in order to simulate a PTO in the laboratory with a dummy system, both mechanisms must be reproduced: for instance, different combinations of loads on the shaft and flywheels.

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SDEWES2018.0431

Optimal Selection of Deployment Site for Wave Energy Devices

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Abstract

Many detailed wave energy resources assessments have been carried out so far. They usually aim to estimate the wave energy availability at a given area of interest, eventually to assess the wave energy extraction by using power matrix of the considered wave energy device. Nevertheless, the wave energy availability is not the only aspect that affects the actual viability of energy extraction projects. Indeed, it has been realized that also the variability of the energy resource plays a crucial role in the selection of the most suitable site where a wave farm may be deployed. In particular, the levelized cost of energy may strongly depend on the wave energy variability as the power take off device should be selected on the basis of such a type of analysis. This paper aims to propose a multicriteria method useful to select the optimal site where wave energy devices should be deployed if the wave energy variability is considered. The method takes into account the wave energy availability, the wave energy variability, the distance from the nearest coast, the extreme wave height and the loss of energy as a function of the rated power of the selected Power Take Off.

SDEWES2018.0244

Modelling and Optimization of Modular System for Power Generation from a Salinity Gradient

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Abstract

Pressure Retarded Osmosis (PRO) has been proposed for power generation from a salinity gradient resource. The process has been promoted as a promising technology for power generation from renewable resources, but most of the experimental work has been at laboratory size. To date, PRO optimization and operation is based on parametric studies performed on laboratory scale units, which leaves a gap in our understanding of its behavior in a full scale modular system. A computer model has been developed to predict the performance of PRO process and optimize key operating parameters. Process modeling has been performed on a full scale multi-modules system and impact of key operating parameters on the process performance has been evaluated.

The results showed that the optimized operating parameters in a laboratory scale PRO unit are not valid in the full scale module. Many studies have suggested that power generation in the PRO process reaches an optimum amount when the hydraulic pressure is equal to. Furthermore, for a PRO process operating under constant pressure, the optimum power generation is achieved at the feed/draw solution fraction in a mixed solution equal to 50%. While these optimum values are valid in a laboratory scale unit or in the ideal PRO process, they are not applicable for a non-ideal PRO process. Simulation results revealed that the optimum hydraulic pressure in the PRO process depends on the salinity gradient and the osmotic pressure gradient across the PRO membrane. Also, feed/draw solution fraction in mixture in entirely dependent on the salinity gradient and the number of PRO modules in the pressure vessel. In fact, the optimized PRO process would operate at a hydraulic pressure less than, hence the characteristics of the PRO membrane and pump specifications are different to that suggested in previous studies. The results here demonstrate that the energy output from the optimized PRO process is up to 54% higher than that in the normal (unoptimized) PRO system. This will encourage further research in salinity power plant technology.

SDEWES2018.0256

A 30-Year Projection of the Future Wind Energy Resources in the Coastal Environment of the Black Sea

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Abstract

In the last years the offshore wind industry shows a very high dynamics, both as regards the development of fix wind turbines and floating platforms. The most significant advances are given by the development of the large wind turbines (10-20MW) and by considering also the multi-rotor approach. Besides the technical issues, the challenge consists in achieving significant reductions of the Levelized Cost of Energy (LCOE). According to many estimations a realistic LCOE target in 2018 for the offshore wind is about 7 c€/kWh and it will continue to decrease in the next years. This means that the offshore wind is already commercially effective being at this moment the cheapest marine renewable energy resource. Moreover, taking into account the fact that the LCOE for the atomic energy is about 11.5 c€/kWh, offshore wind becomes now cheaper also than some conventional onshore resources. It is thus expected that in the near future a significant development of the marine wind farms will be noticed in many coastal areas. From this perspective, the objective of the present work is to evaluate the wind energy resources in the coastal environment of the Black Sea by providing a reliable projection for the next 30 years. At this level of the work, the wind power is assessed from the coast and up to 100 meters water depth. The wind speeds considered are those provided by the regional climate model from the Rossby Centre (RCA4) and predicted under the RCP 4.5 and RCP 8.5 scenarios used in Climate Model Intercomparison Project (CMIP5). The time interval is 2021-2050, the wind speeds having a spatial resolution of 0.11 degrees, with 6 hour temporal resolution. The analysis of the historical data provided by these climate wind models shows reliable results in the basin of the Black Sea, which gives also a reasonable degree of confidence for 30-year future time window considered. Although from the point of view of the wave energy, the Black Sea cannot be considered with high potential, especially when compared with the ocean coasts, as regards the wind power resources the potential of this coastal environment is in line with other coastal areas where such marine wind farms already successfully operate. Finally, it can be concluded that the present work provides a comprehensive and useful picture of the future wind energy resources in the coastal environment of the Black Sea.

SDEWES2018.0318

A Numerical Investigation of Wave and Tidal Current Energy Resource Potential in the Strait of Novsko Ždrilo

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Abstract

Compared to wind and solar, forms of variable renewable energy resources with most mature technologies for energy conversion, tidal current energy resources are predictable hundreds of years in advance. Meaning that tidal current energy can bring stability and predictability to the power grid. An important initial step towards market deployment of tidal current energy, and also wave energy, is the characterization and mapping of their energy resources potential. The assessment of wave and tidal current energy resources includes the identification of areas with high energy potential, the quantification of average energy resources and the description of the resource by using parameters that are characteristic for wave and tidal current energy. This will help to optimize energy converting device's performance in terms of power production.

Over the years, due to the increased availability of affordable and powerful computers, the use of numerical techniques has become a very useful and cost-effective tool for mapping of energy resource potentials. The aim of this paper is to present an advanced 3D modelling technique for estimation of tidal current energy resource potential. The modelling technique was applied to study the hydrodynamic phenomena occurring in the strait of Novsko ždrilo. A detailed hydrodynamical modelling was used in order to obtain reliable results for tidal currents for the studied location. The results gained by this study can be used for better understanding of the complex hydrodynamic phenomena occurring in the analysed strait and to map potential future locations for tidal current energy converters.

SDEWES2018.0415

Offshore Wind Turbine Unsteady Wake Modelling by a Panel Method

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Abstract

In this paper the performance of a horizontal axis wind turbine operating in axial uniform and non-uniform onset flow are investigated. Under the assumption of attached-flow conditions, rotor and blade aeroloads along with the structure of the vorticity field downstream the rotor disk are predicted by an unsteady, three-dimensional free-wake panel method for subsonic potential flows. Numerical results and available experimental data are compared to highlight potentialities and drawbacks of panel methods-based solvers for fast and reliable aerodynamic predictions. To this aim, the Mexico model-scale rotor, extensively tested in the German Dutch Wind tunnel, is considered. The quality of numerical outcomes respect to experiments proves that panel method rotor aerodynamics is accurate enough as long as severe flow separations do not occur on turbine blades, thus avoiding time-consuming Computational Fluid Dynamics analysis that are often not compatible with a preliminary design of the device. In addition, the case study of the Mexico model-scale rotor subject to an extreme vertical shear and the analysis of a floating wind turbine are presented.

SDEWES2018.0432

Assessing Risk to Bridge the Valley of Death of Seabed Mining of Polymetallic Nodules in the Clarion Clipperton Fracture Zone

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Abstract

Metal demand is increasing due to global population rise and increasing urbanisation. Metal demand is also growing to meet society's clean energy goals, which typically involves employing metal-intensive technologies. At the same time, land-based mineral resources are becoming stretched. As a result, society is looking for new sources of minerals and metals. Polymetallic nodules found on the surface of the abyssal plains between the Clarion and Clipperton Fracture Zones in the North Pacific Ocean contain more cobalt, nickel and manganese than all land-based reserves combined. While the commercial development of polymetallic nodules may offer a viable and potentially more environmentally and socially attractive alternative to land-based mining, it requires early stage, breakthrough, subsea mining technologies to be developed. However, the process of commercialising non-incremental early stage technology developments is often associated with market failures; a process often referred to as bridging the Valley of Death (i.e. ensuring innovations do not fail prior to commercialisation). This paper focuses on the interconnectivity between market (financing), completion (technical) and institutional risks (regulatory, sovereign and social acceptability) and offers risk mitigation strategies that can be applied to reduce uncertainty. As these seafloor polymetallic nodules are located beyond the limits of national jurisdiction, an international regulatory framework for exploitation is under development by 2020. The timeline for the adoption and approval of the regulations offers a window of opportunity to provide insights for decision-makers on the key issues that need to be overcome in order to bridge the Valley of Death, thereby fostering technological change and creating significant welfare.

SDEWES2018.0461

Improving the Hydrodynamic Performance of Hydrokinetic Turbines by Using Additional Stator Elements

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Abstract

Hydrokinetic turbines are an emerging technology for the exploitation of mostly untapped energy contained in river streams, waves and tidal currents. In spite of numerous economic and environmental benefits over conventional hydropower technology, wide commercialization of the technology has not been achieved so far. This is primarily due to relatively low efficiency, bounded by a theoretical limit, known as the Betz limit. The objective of this paper is to investigate the potential of overcoming the efficiency limitation by using additional stator elements while keeping simplicity in design, which is one of the main advantages of hydrokinetic turbines. To validate the proposed design improvements, computational fluid dynamics is used. Different shapes and geometries of stator parts are taken into consideration to find the shape that best meets the specified design requirements. The results show improved hydraulic efficiency, relative to the efficiency of the bare rotor design, as a consequence of increased flow velocity at the rotor plane. However, significant increase in efficiency is not achieved with all the considered geometries which indicates the necessity of selecting an optimal stator geometry, to justify the additional cost by increased efficiency.

Special session: Waste Heat Recovery and Utilization

Nowadays, energy consuming and corresponding environmental pollution have become world's two prominent problems. Last couple of decades has witnessed extensive embracing of energy efficient, cost effective and miniaturization technologies in a variety of products and processes of energy conservation and pollution reduction. Typical applications can be found in heat exchangers, gas turbine cooling, fuel cell, solar energy utilization, electronics cooling, biofuels technologies etc., where heat transfer plays a major role inside. This special session aims to provide an international forum for the exchange of latest technical information, for the dissemination of high-quality research results and for the presentation of recent advances on waste heat recovery and utilization problems in energy conservation and pollution reduction areas. This issue will be of particular value and interest to researchers, scientists, engineers and practitioners who are working in waste heat recovery and utilization fields of energy conservation and pollution reduction.

Session organizers:

Prof. Qiuwang Wang, Xi'an Jiaotong University, Xi'an, Shaanxi, China

Prof. Jian Yang, Xi'an Jiaotong University, Xian, China

Qiuwang Wang - Dr. Qiuwang Wang is now a full professor and vice-Dean of School of Energy and Power Engineering, Xi'an Jiaotong University. He is also the vice-Director, MOE Key Lab of Thermo-Fluid Science and Engineering, China. His research interests include heat transfer enhancement and its applications to engineering problems, high-temperature heat transfer and fluid flow, transport phenomena in porous media, numerical simulation, prediction & optimization, etc. Dr. Qiuwang Wang is now a member of Scientific Council of the International Centre for Heat and Mass Transfer (ICHMT) since 2009, a Committee Member of Heat Transfer Division K-18 of ASME: Heat Transfer under Extreme Conditions since 2009, a board committee member of International Academy of Electrochemical Energy Science (IAOEES) of Canada since 2014, a member of ASME since 2009, an Associate Editor of Heat Transfer Engineering Journal since 2011, and Editorial Board Members for several international journals such as Applied Thermal Engineering, Frontiers in Energy, International Journal of Engineering Systems Modelling and Simulation, etc. He is also a vice president of Chinese Society of Engineering Thermophysics in Heat and Mass Transfer. He is the Initiator and Chairman of International Workshop on Heat Transfer Advances for Energy Conservation and Pollution Control (IWHT) (since 2011, 2011-Xi'an, 2013-Xi'an, 2015-Taipei). He has also delivered more than 30 Invited/Keynote lectures in international conferences or foreign Universities. Dr. Qiuwang Wang has instructed or co-instructed more than 60 PhD or master students, among which about 30 had obtained their corresponding degrees. He has also been authors or co-authors of 4 books and more than 180 journal papers, about half of which are international journals. He has obtained 25 China Invent Patents and 2 US Patents.

Jian Yang - Dr. Jian Yang received his Ph.D. degree in Power Engineering and Engineering Thermophysics from Xi'an Jiaotong University in 2010. He is now an associate professor of School of Energy and Power Engineering, Xi'an Jiaotong University. He acts as reviewer for several international journals, such as Applied Energy, Applied Thermal Engineering, Experimental Thermal and Fluid Science, ASME Journal of Heat Transfer, International Communications in Heat and Mass transfer, etc., and several Chinese Journals. His main research interests include transport phenomena in heat recovery from packed or gravity flowing beds of particles, Computational Fluid Dynamics and Numerical Heat Transfer (CFD&NHT), heat transfer enhancement, etc. He has also been authors or co-authors of more than 20 international journal papers.

Invited submissions

SDEWES2018.0214

Numerical Study on the Performance of Methane Steam Reforming in Grille-Sphere Composite Structured Packed Bed

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Abstract

Thermochemical reaction energy storage is considered to be promising in high temperature waste heat recovery and solar energy storage because of its high energy density, wide temperature range as well as feasibility for long duration energy storage. Methane steam reforming, which is a highly endothermic and high temperature reaction, is suitable for high temperature energy storage. Packed bed reactors have been used widely in methane steam reforming reaction as well as other chemical reactions. However, the high pressure drops as well as radial heat transfer problems may occur in traditional random packed bed reactors in highly endothermic or exothermic reactions. To solve this problem, a kind of grille-sphere composite structured packed bed (GSCSPB) has been proposed. In the GSCSPB, a monolith is inserted into the tube and the catalytic particles are filled in the channels. The monolithic structure is made of materials with high conductivity to enhance the ability of radial heat transfer. The GSCSPB can be seen as a set of narrow packed beds, whose tube-to particle diameter ratios are between 1.00 and 2.00. Pressure drop and heat transfer performances of unit cells of GSCSPB have been experimentally and numerically studied in previous researches. However, the reaction performance has not been considered. Besides, the structure of unit cells may have an influence on the performance of reaction. As a result, numerical simulations of methane steam reforming in packed beds with tube-to-particle diameter ratios between 1.00 and 2.00 were conducted to optimize the structure of unit cells of GSCSPB in the present paper. Three-dimensional Navier-Stokes equations and SST k--w turbulence model were adopted. The solid particle method was used to simulate the chemical reaction and species diffusion inside the catalyst particles. Four user-defined scalars were used to represent species inside catalytic particles and the chemical reactions were model with user-defined functions. Cylindrical bridges were inserted at particle-particle and particle-tube contact points to solve the meshing problems. The bridge diameter was set to be 20% d_p. Mesh independence validation has been conducted by varying the grid size of particle surface and prism boundary layers inside the particle. In order to validate the simulation of flow, heat transfer, diffusion and reaction, CFD results were compared with correlations of friction factor and Nusselt number and experimental results of methane steam reforming reaction. The maximum deviations for flow and heat transfer were less than 5% and for chemical reaction were less than 15%. The results showed that the effective heat transfer per pressure drop increased with higher porosity and the packing form was found to be crucial for heat transfer and conversion of reactants.

SDEWES2018.0280

Thermodynamic Analysis of a Novel Compressed Liquid Carbon Dioxide Energy Storage System

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Abstract

The renewable energy including photovoltaic generation and wind power generation has the characteristics of intermittence, variability and uncertainty. Their integration into the grid leads to the power fluctuations and further makes the stability of power system facing enormous challenges. Thus, a renewable power system with an ancillary energy storage system can weaken the negative effect. In this paper, a novel compressed liquid carbon dioxide energy storage system is proposed by introducing a turbine and an expander to recovery the residual heat. The effects of some key thermodynamic parameters on the system performance are investigated. The net power output, round trip efficiency (RTE) and exergy destruction are evaluated. The results show that the proposed system can store surplus electricity generated by renewable energy and play a role of peak shaving and valley filling for electric network with appropriate parameters. The compressor contributes mostly to the exergy destruction under the design conditions. System RTE can reach 64.27% at studied conditions. Based on the analysis above, the proposed system can be considered in practical cases for solving the intermittency of renewable power.

SDEWES2018.0326

Thermolytic Red- Heat Engine: First Experimental Assessment

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Abstract

Reverse electrodialysis heat engine is a promising technology for converting low-temperature waste heat into electricity. This innovative heat engine consists of two units: (i) a reverse electrodialysis unit where the concentration difference between a diluted and a concentrated salt solution is converted into electricity and (ii) a thermal regeneration unit where waste heat is used to restore the initial conditions of the two streams.

Thermolytic salts solutions, and in particular Ammonium bicarbonate solutions, have been proposed as working fluids in such application due to their peculiarity: the salt ions dissolved in water are converted into ammonia and carbon dioxide when heated up above a certain temperature (around 60°C). Then, dissolved thermolytic salt can be removed nearly completely from the dilute solution by means of a thermal desorption process and absorbed again in the concentrate solution, thus restoring the salinity gradient exploited by the reverse electrodialysis unit.

In the present work, for the first time a lab scale prototype of a RED-HE was built and tested. The proposed experimental RED-HE consists of a reverse electrodialysis unit and a regeneration unit constituted by (i) a vapour stripping column and (ii) a barometric column. An experimental campaign was carried out in order to evaluate the effect of some operating conditions, such as solutions concentrations and flowrates, on the performance of the system. First experimental results demonstrated the feasibility of the process.

SDEWES2018.0348

Numerical Simulation and Optimization of Waste Heat Recovery in Sinter Vertical Tank

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Abstract

The efficient recovery of sinter waste heat resource is one of the main ways to improve the energy utilization efficiency of sintering process in the iron and steel industry. In this paper, a two-dimensional steady computational model is established to investigate the gas/solid heat transfer in vertical sinter bed based on the porous media theory and the local thermal non-equilibrium model. In order to improve the overall heat transfer performances and reduce the pressure drops of the vertical tank with the same structural parameters, the effects of air flow rate, sinter flow rate, sinter particle diameter, sinter initial temperature are studied numerically by changing one parameter to different levels while keeping other parameters fixed. The local exergy destruction rate is put forwarded to express the gas solid heat transfer performance in the vertical tank. The numerical results show that the outlet air and sinter temperatures increase while decreasing the air flow rate or increasing the sinter flow rate. Increasing the sinter particle diameter, the outlet air temperatures decrease and the outlet sinter temperatures increase. And the outlet air and sinter temperatures both increase with sinter initial temperature increasing. The pressure drops decrease while increasing the air flow rate or the sinter particle diameter and decreasing the sinter flow rate or the sinter initial temperature. Furthermore, in order to get better comprehensive performance, the BP neural network combined with multi-objective genetic algorithm is applied to obtain a set of optimized parameters with the local exergy destruction rate and the pressure drop as the two objectives.

SDEWES2018.0356

Off-Design Performance Prediction of a Supercritical CO2 Brayton Cycle for Waste Heat Recovery from Gas Turbine

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Abstract

The supercritical carbon dioxide (sCO_2) recompression Brayton power cycle for waste heat recovery (WHR) from high-temperature heat source has favorable qualities because of its simplicity, compactness and higher efficiency. With respect to WHR, the primary goal is to maximize the net output power by incorporating the utilization of the waste heat in conjunction with the cycle thermal efficiency. In this paper, a control strategy is proposed and the off-design performance analysis of a sCO_2 recompression cycle applied to the waste heat recovery from a gas turbine is conducted. Prediction of the system performance with the variation of compressor inlet temperature from 32°C to 50°C is carried out. According to the calculations, both the system net power output and heat demand decrease with the rise of the compressor inlet temperature, and cycle thermal efficiency declines by up to 8% compared to the design value. On the other hand, the efficiency of the turbomachineries reduces slightly, which indicates the feasibility of the proposed control strategy under off-design conditions.

SDEWES2018.0384

An Integrated Technology Combing Efficient Purification and Waste Heat Recovery for Flue Gas with High Temperature and High Dust Content

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Abstract

High temperature flue gas (> 800 C) with a higher energy grade and a greater recycle value is usually generated in metallurgical, petrochemical, building materials, electric power and other process industries. Those energy are difficult to be recycled due to the high dust content (≥2000mg/m^3), and occasionally corrosive- and cohesive-materials in the gas. Herein, in order to solve the bottleneck problem of efficient waste heat recovery from flue gas with high temperature and high dust content, a novel integrated technology combing with purification and waste heat recovery processes is proposed in this study. The three-dimensional metal honeycomb with oversized surface and the stainless steel fiber cloth (SSFC) with dense woven are the main important components in the integrated technology. Through the structure and heat transfer characteristics simulation and the actual orthogonal experiment design, the optimized structure and size of the three-dimensional metal honeycomb are obtained. According to the experiments studies, the heat transfer and purification characteristics of the integrated technology are represented. Two structure parameters (different the honeycomb porosity and the mesh numbers of SSFC), and three different conditions (different the flue gas inlet temperatures, the filtration velocity, and the dust inlet concentrations) are designed for measuring the heat recovery and purification performance. The results show that with the honeycomb porosity fixing in 0.4-0.8 and the SSFC mesh number setting in 500-1500, the waste heat recovery rate of the technology can achieve more than 70%, and the purification efficiency can reach to 99.8% or higher at the same time under a lower resistance condition.

SDEWES2018.0224

One-Dimensional Heat Conduction in the Fractal Semi-Cokes

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Abstract

The semi-cokes carry a lot of waste heat and the inner morphology of semi-cokes has great effects on heat conduction characteristics, so the inner morphology and heat conduction characteristics of semi-cokes were investigated. The non-destructive CT was employed to obtain the inner morphology of semi-cokes and the image binarization processing was used to segment the image. With the MATLAB program, the fractal dimension, porosity and average number of contact of semi-cokes were calculated. The DRS-III thermal conductivity tester was used to measure and calculate the temperature distribution, heat flux and equivalent thermal conductivity of semi-cokes. The effects of inner morphology on heat conduction characteristics of semi-cokes were studied. The effective thermal conductivity formula derived from fractal theory, and the formula takes into account the geometric structure, the thermal contact resistance and equivalent diameter of semi-cokes. The results showed that, with increasing the diameter of semi-cokes from 3mm to 37mm, the fractal dimension and average number of contact decrease gradually, but the porosity, the temperature, the heat flux and equivalent thermal conductivity increase gradually. With the decrease of the fractal dimension and the average number of contact, the heat flux and equivalent thermal conductivity increase gradually, and the effect of porosity on the heat flux and equivalent thermal conductivity is less than the fractal dimension and average number of contact. The fractal expression of the equivalent thermal conductivity for semi-cokes was obtained and it can describe the heat conduction of semi-cokes very well.

SDEWES2018.0255

Comparative Thermo-Economic Analysis of Structured Thermocline Combined Sensible-Latent Heat Thermal Energy Storage Systems for Medium Temperature Applications

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Abstract

The pressing global challenge to address sustainable energy development, energy security and global warming has lead the researchers to focus their efforts to innovate advance green energy technologies. In current work a thermocline combined sensible-latent heat thermal energy storage (TES) is proposed as an alternative to the currently used TES systems; containing solid rod structure of cheap naturally occurring material brick manganese with Phase Change Material (PCM) capsules impregnated between them. The issues of thermal ratcheting and material settlement are overcome by using structured rod and the use of PCM capsules provide stable fluid outlet temperature around its phase change temperature. A comprehensive unsteady numerical model is formulated based on two-phase Schumann model equations to simulate the discharging performance of the proposed hybrid TES configuration for medium temperature applications. The numerical model is implemented as User Defined Scalar transport equations in FLUENT. The model is validated separately for sensible and latent heat storage sections using experimental data from previous literature. The numerical simulations are performed to compare the proposed storage system (Case-3) economically and performance wise with sensible TES (Case-1) and latent heat TES systems (Case-2). The influence of different evaluation indexes of TES performance such as axial temperature distribution, fluid outlet temperature, thermocline degradation, effective discharging time and effective discharging efficiency (EDE) are studied. The results of the comparative study show that for the same tank size and operating conditions; TES system for Case-2 has higher EDE of 95%, whereas Case-3 and Case-1 possess 87% and 76% respectively. However, it results into comparatively higher pump energy of 3958 kJ required to overcome the pressure drop for Case-2 than Case-1 and Case-3 requiring only 15 kJ and 2481 kJ respectively. The adopted comprehensive cost model indicates that Case-2, Case-3 and Case-1 has the capacity cost of $42/kWh, $37/kWh and $35/kWh respectively. Moreover, the capital cost of the proposed system is 30% higher than that of Case-1 but it is 45% more cheaper than Case-2. The study suggests combined sensible-latent heat TES system seems to be more viable option among the considered cases due to its optimized performance, reduced thermocline region, comparatively low cost and the reason that thermal ratcheting of the storage tank can be avoided with stable fluid outlet temperature.

SDEWES2018.0272

Sliding-Pressure Operation Behavior of an Organic Rankine Cycle for Low Grade Heat Recovery

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Abstract

With the increase of global energy consumption, large amount of low-grade heat energy has been discharged directly into the environment, causing energy waste and environmental pollution. Organic Rankine cycle (ORC) which approved to be a promising technology to recover low-grade heat source has been investigated widely recently. Considering the instability of the low-grade heat source, its temperature and mass flow rate varied due to the unstable industrial process, consequently, the ORC system wouldn't always operate at its design condition. The aim of this study is to examine the system performance of a regenerative ORC when off-design conditions occurred. Mathematical models of ORC system including key components (heat exchangers, turbine and pump) and axial turbine loss model were established. Sliding-pressure control strategy, which kept the temperature difference between turbine inlet temperature and heat source temperature constant by regulating the turbine inlet pressure, was adopted to control the ORC system. An ORC experimental system including an axial turbine, an electrical heater and two plate heat exchangers (condenser and recuperator) was tested to validate the mathematical models. Under the changing of low-grade heat source temperature (regulated by electrical heater) or working fluid mass flow rate (regulated by working fluid pump), the off-design performance of the ORC system was examined using the mathematical model. The results indicated that ORC system net power and thermal efficiency increased with the increase of low-grade heat source temperature or working fluid mass flow rate. What's more, turbine efficiency would be lower when turbine operated at the conditions deviating from the design condition.

SDEWES2018.0295

Simulation and Experimental Study on Geometry Optimization of Thermoelectric Modules

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Abstract

Thermoelectric generator (TEG) is attracting increasing attention for its application in waste heat recovery. A typical TEG is composed of multiple thermoelectric modules (TEM) and the heat transfer device, and TEM is the most critical and basic components. Currently most existing commercial TEM has fixed geometry, and customers purchase those commercial TEM without adjusting TEM geometry for specific application. However, previous investigations show that the geometry design of TEM can have significant influence on the output power. In this study, both simulation and experimental investigations are conducted to optimize the TEM geometry in terms of output power. Simulation study shows that, to achieve optimal output power, TEM height is preferred at around 2-3mm while a larger TEM couple number is always preferred. Experimental setup is built and two TEMs with different geometry is tested. The experimental results agree well with the simulation results.

SDEWES2018.0354

Off-Design Analysis of a CO2 Rankine Cycle with LNG as the Cold Source Driven by Ambient Air

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Abstract

In this study, a simple CO_2 Rankine cycle using LNG as the cold source was proposed. The system is driven by ambient air, which is regarded as one of the most convenient and economic heat source. For the reason that the ambient temperature changes with days and seasons, it is necessary to take into account the off-design behavior of the system. In this paper, an off-design performance analysis was carried out for the system. A detailed mathematical model for the off-design operation of the system was established to evaluate the variations of system performance with the heat source temperature and mass flow rate. The results show that with the decrease of temperature and mass flow rate of heat source, turbine inlet pressure, turbine power output and heat transferred in evaporator and condenser decrease greatly, as well as the system thermal efficiency. But pump power consumption and efficiency changes slightly. Furthermore, the turbine efficiency achieve maximum at design condition, and decrease greatly at off-design condition.

SDEWES2018.0273

Off-Design Performance Comparison of a Kalina Cycle, a Single-Pressure ORC Using Zeotropic Mixtures and a Dual-Pressure ORC Using R245Fa

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Abstract

The Kalina cycle, single-pressure ORC (SORC) using zeotropic mixtures and parallel dual-pressure ORC (DORC) are promising solutions to reduce the exergy destruction of evaporator during the recovery of low-grade waste hot water. This paper develops off-design models for these power cycles. Net powers and heat transfer areas are compared by adopting the particle swarm optimization algorithm at the design heat source parameters (10 kg/s and 130 °C). Off-design waste hot water parameters and environment temperatures are considered by the sliding pressure operation approach. The results show that the DORC using R245fa shows the largest net power of 261 kW, which is 10.64% more than the SORC using R245fa/R600a (0.423/0.577 mass) does and 30.87% more than the Kalina cycle does. The Kalina cycle shows the smallest heat transfer area per net power. As the waste hot water mass flow rate increases, the net power ratio of SORC to Kalina cycle decreases firstly and then increases, while the net power ratio of DORC to Kalina cycle increases. At larger waste hot water mass flow rate, the net power difference between SORC and Kalina cycle is strongly influenced by the waste hot water inlet temperature and the environment temperature.

SDEWES2018.0297

Experimental Investigation on Overall Performance of a Printed Circuit Heat Exchanger with Zigzag Fins in a CO2-Water Loop

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Abstract

Printed circuit heat exchanger (PCHE) is considered as one of the most promising candidates for recuperator in the fast cooled reactor system, which performs good high pressure, high temperature resistance and long-term operation reliability. PCHE is manufactured by the photochemical etching and diffusion bonding technologies, which yield reasonable cost and high compactness. This research investigates the effect of inlet parameters and working conditions on the overall performance of a PCHE with zigzag fins. The total heat transfer coefficient and the comprehensive heat transfer performance under different mass flow rates, inlet pressures and temperatures are examined, including the trans-critical and supercritical conditions. The results show that the total heat transfer coefficient increases with the increase of mass flow rate and pressure, but performs the opposite changes with the increase of inlet temperature. The overall performance at supercritical condition is superior to that at trans-critical condition. A new factor of working point is proposed to evaluate the performance of PCHE in the CO_2-water loop, which is more suitable than the inlet temperature.

SDEWES2018.0346

A Thermal Driven Solution Pump for Ammonia Water Absorption Power Systems

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Abstract

Ammonia water absorption system is advantageous on efficient use of waste heat to produce power due to the temperature glide in the evaporation process. A mechanical pump characterized as high hydraulic head and low flow rate is the chief drawback for a small capacity ammonia water absorption power system. This paper proposes a thermal driven solution pump assisted by gravity instead of a conventional mechanical pump to circulate the solution. Three vessels in vertical arrangement constitute the thermal driven solution pump. The intermediate vessel alternately connects to the higher vessel at constant low pressure and the lower vessel at constant high pressure through the control of three magnetic valves and two one-way valves, making solution charging and discharging available. A floating plank is placed on the liquid surface in the vessels preventing absorption. A thermodynamic model is conducted to investigate the features of the operation of the thermal driven pump. The geometric parameters of the vessels can be designed based on the switching period of the magnetic valves. The vapor consumption is calculated and its effect on the system performance is analyzed. The net power out and the thermal efficiency are anlayzed with different operating conditions.

SDEWES2018.0349

Numerical Investigation on Heat Transfer Performance of Packed Bed

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Abstract

The development of direct heat transfer enhancement technology between fluid and packed bed is very important for high efficiency recovery and utilization of waster heat resource in sintered process. In this paper, numerical simulation method is adopted to investigate the heat transfer principle between particles and fluids, and the primary purpose is to develop the direct enhanced heat transfer technology in the dense phase flow. The fluid is treated as a continuous phase and solved by Computational Fluid Dynamics (CFD), while the particles are treated as discrete phase and solved by the Discrete Element Method (DEM). The simulation focused on the effects of particle diameter distribution, the shape of the particles and the flow of fine powder on the overall heat transfer performance and the wall effects. The heat transfer performance is mainly evaluated by the temperature and the exergy of the cooling air at the outlet while the wall effect is evaluated by the porosity near the wall area. Different particle size distributions have different effects on heat transfer performance and wall effects. Multi-particle size distribution has better heat transfer performance than a single particle size distribution, and weak wall effect. The more particles with different particle sizes, the better the heat transfer performance and the less obvious the wall effect. Meanwhile, mixing fine powders in a single-particle packed bed can improve heat transfer performance to some extent and reduce the effects of the wall effect. Different particle shapes lead to different flow patterns and the local turbulence intensities, which affects the overall heat transfer performance. Based on the calculation results, we will seek an optimal particle sizes distribution to maximize the heat transfer performance.

SDEWES2018.0375

Comparative Study of the Air Source Heat Pump Water Heater with and Without Liquid-Separation Mini-Channel Condenser

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Abstract

Air source heat pump water heater (ASHPWH) is low-cost, easy in install and safe in use. Compared to electric and gas water heaters, it makes a better use of the energy from air and has two to three times higher efficiency.. In residential application, the condenser in ASHPWH is normally coupled with the water tank and is of great importance for the heat transfer efficiency to water. It has been demonstrated that using the minichannel condenser in the heat pump water heat could reduce refrigerant quantity significantly, and improvement of the system COP could be as high as 0.5.

In this study, the liquid-separation condenser (LSC) is attempted to improve the ASHPWH with minichannel condenser. LSC is able to enhance the heat transfer coefficient and decrease the pressure drop simultaneously. Moreover, applying LSC in air-conditioning systems can also improve the system performance. The processes in ASHPWH are dynamic instead of steady. The objective of this paper is to exam the feasibility of LSC in ASHPWH by means of comparing to same ASHPWH but having a regular minichannel condenser without liquid-vapor separator.

The prototype ASHPWH has a minichannel condenser that is placed wrapped the water tank, named as Unit A. It is carefully sized and examined by the manufacturer. As a primarily investigation, LSC is made to the same as the prototype condenser with an exception that LSC has liquid-vapor separators whilst the prototype condenser has the baffles. The ASHPWH with the LSC is termed as Unit B. The two units have the same compressor and evaporator, and use R22. Under Chinese standard GB/T 2317-2008, the experiments are carried out to obtain the maximum COP by adjusting the capillary tube length and refrigerant charge for Unit B. The maximum COP is observed at 4.14, which is 0.1 higher than that of Unit A. Unit B has also benefits over Unit A in terms of heat capacity and power consumption. The sensitive analysis further shows that the heat capability decreases with the increasing of time.

It is noted that although the improvement of COP, i.e. 0.1, is not very significant, LSC is not bringing more cost since it is made from the prototype condenser by simply adding several small holes on some baffles as liquid-vapor separators. It is strongly believed that the performance of Unit B can be further improved by optimizing the passage arrangement and liquid-vapor separators.

SDEWES2018.0383

An Efficient Waste Heat Reclamation System for Solid Particles Producing from Rotary Kiln

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Abstract

The waste heat of solid particles including solid products and residues in industrial production per year of China is approximately equivalent to the heat of 1 million tons of standard coal, which is in a large amount and is worth to be reused. As a typical equipment producing solid particles in wide distribution of size and temperature, the rotary kiln is urgent to be focused on. Herein, efficient waste heat recovery systems that can be applicable to different rotary kiln is established and applied to industrial practice. For rotary kiln with high ground clearance, vertical heat recovery systems are developed. To enhance the heat transfer rate in the gas-side, plug-in components including SiC-honeycomb and metal-honeycomb type, with specific surface area 100~2000 m^2/m^3 are designed. By heat balance calculation, the heat recovery efficiency of vertical type system with SiC-honeycomb embedded can up to 90%. For rotary kiln with low ground clearance, a horizontal heat recovery system with discontinuous screw leaves is designed. The screw leaves can not only result in an efficient heat recovery, but also lead to a uniform discharge of solid particles. Through industrial application of vertical recovery systems, the waste energy gets efficient reuse and can reduce the fuel cost of rotary kiln by 4 ~9 million RMB per year.

Special session: Renewable energies, innovative HVAC systems and envelope technologies for the energy efficiency of buildings

The need to increase the sustainability and energy efficiency of buildings has led to the development and implementation of innovative buildings design criteria and standards with special attention to the integration of renewable energies, use of innovative HVAC systems and implementation of new building envelope technologies.

The goal of this special session is to present new research results, case studies and practices aimed at reducing the energy demand of residential, commercial, public, and industrial buildings, by also decreasing the related environmental impact and improving the occupants' comfort. Specifically, the special session is dedicated to the following topics:

- Automation and innovative control for HVAC systems in buildings;
- Building integrated renewable energy systems;
- District heating and cooling;
- Energy sustainability, resilience and climate adaptability of buildings;
- Heat recovery systems in buildings;
- Geothermal heat pumps systems;
- Innovative HVAC&R systems;
- Life cycle energy efficiency of buildings and embodied energy;
- Natural, mechanical and hybrid ventilation;
- Passive envelope technologies and new materials;
- Solar heating and cooling;
- Thermal energy storage and thermally active building systems.

Session organizers:

Dr. Annamaria Buonomano, University of Naples Federico II, Napoli, Italy

Prof. Soteris Kalogirou, Cyprus University of Technology, Limassol, Cyprus

Prof. Adolfo Palombo, University of Naples Federico II, Naples, Italy

Annamaria Buonomano - Annamaria Buonomano obtained a B.Sc. and a M.Sc. in Engineering Management summa cum laude in 2004 and 2006 from University of Naples Federico II and a Ph.D. in Energetics from University of Palermo in 2010. She was visiting scholar at the Energy Performance of Buildings Group of the Lawrence Berkeley National Laboratory (Berkeley, USA) in 2009, researcher at the Ben Gurion National Solar Energy Center of the Jacob Blaustein Institutes for Desert Research of University of Ben-Gurion (Sde Boqer, Israel) in 2011, and several times visiting scientist at Concordia University (Montreal, Canada), where she was appointed as Affiliate Assistant Professor in the Department of Building, Civil and Environmental Engineering in 2017. She is actively involved in research topics regarding building energy efficiency, with a particular focus on the development of performance simulation models and investigation of innovative building-plant solutions, based on integrated construction techniques, innovative HVAC systems and novel renewable energy technologies including solar heating and cooling systems, concentrating photovoltaic solar thermal systems, polygeneration. She is also involved in collaborative research activities relative to the design of net zero energy buildings and the integration of passive solar thermal systems in buildings.

Soteris Kalogirou - Soteris Kalogirou was born in Trachonas, which is a suburb of Nicosia. He is married and has two children. He received his first Degree in Mechanical Engineering from the Higher Technical Institute (1982) his Master of Philosophy (M.Phil) in Mechanical Engineering from the Polytechnic of Wales (1991) and his Ph.D in Mechanical Engineering from the University of Glamorgan, UK (1995). In June 2011 he was awarded from the University of Glamorgan, UK the title of D.Sc. He was employed as a Building Services Consultant by the firm Intersol Engineering from 1982-1987, and in various positions in the Mechanical Engineering and Engineering Practice Departments of the Higher Technical Institute from 1987 to 2007. In 2008 he was transferred to the Cyprus University of Technology and now he is a Senior Lecturer in Mechanical Engineering. He is considered internationally as an expert in the field of solar thermal collectors and to the use of artificial intelligence techniques for the performance prediction of energy and renewable energy systems. He is member of CIBSE (Chartered Institution of Building Services Engineers), Chartered Engineer (C.Eng), member of FEANI (Eur Ing), member of ASHRAE (American Society of Heating, Refrigerating and Air-Conditioning Engineers), member of ISES (International Solar Energy Society) and member of the Institute of Refrigeration (IoR). He is Editor-in-Chief of Renewable Energy Journal and Deputy Editor-in-Chief of Energy Journal. He is Adjunct Professor in Dublin Institute of Technology and Visiting Professor in Brunel university.

Adolfo Palombo - Adolfo Palombo obtained a M.Sc. in Mechanical Engineering summa cum laude in 1992 and a Ph.D. in Thermo-Mechanical Systems in 1997 from University of Naples Federico II. He was visiting scholar in the Energy and Analysis Program, Energy and Environment Division, at the Lawrence Berkeley National Laboratory (LBNL), Berkeley, California, U.S.A. in 1995. During his research activity, he has been actively involved in research fields concerning energy technologies for civil, hospital and industrial applications, such as heating and cooling of buildings, thermo-fluid dynamic measurements, power systems, renewable energy and innovative HVAC systems for energy efficiency and Net Zero Energy Building (NZEB). He is also involved in the development of dynamic building energy simulation tools for the assessment of energy, economic, and environmental performances of the investigated innovative systems, publishing more than 150 publications on international scientific journals and refereed conference proceedings. He is responsible of several scientific agreements with European and Canadian universities and research institutes with the aim to further collaborative research and teaching activities on solar energy applications. He is also responsible of several funded research projects regarding the energy efficiency of systems and buildings. In addition, he is member of the board of experts in the permanent supervisory committee of the Italian Regulatory Authority for Energy, Networks and Environment (ARERA). He is member of the Analysis Committees at the Direction for audits of Italian Energy Services Management (GSE SpA). Specifically, he is member of the Committee n. 1 (experts on thermo-electric systems fed by biogas, landfill gas, gas obtained by depuration processes and bio-liquids) and Committee n. 3 (experts on high efficiency cogenerative thermo-electric systems). He is member of the experts committee for reviewing and evaluating research projects funded by Italian Ministry for Industry. He is also member of the Management Committee of the International Building Performance Simulation Association – Italian Division (IBPSA-Italy). He was member of the Management Committee of Action TU1205 (Building Integration of Solar Thermal Systems, BISTS) of the European COST (Cooperation in Science and Technology).

Invited submissions

SDEWES2018.0162

Innovative Living Wall for Mediterranean Climate: Numerical Optimization of Designing Parameters

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Abstract

In order to evidence how green walls can provide sustainable solutions in Mediterranean climate, a numerical analysis, by means of EnergyPlus, is presented for the evaluation of the optimal configuration to be installed in South Italy.

The methodological approach is divided in two main steps; firstly, a parametric study is proposed considering the application of green module on south exposure by varying plants' type, substrate's materials, air-gap characteristics, thickness of main materials. This comparison regards both the minimization of heating and cooling load that the improvement of indoor thermal comfort and the reduction of polluting emissions. The indications obtained from the examination of the results, are subjected to a further multi-objectives optimization analysis by means of genetic algorithm.

Three solutions are placed on Pareto front, all with exposure of the green system on west side; the compromise solution is characterized by lower insulation thickness on inner side and maximum one on outer side, with graminaceous plants and polypropylene as substrate.

SDEWES2018.0229

Deep Retrofitting Result Assessment Using Different Simulation Tools

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Abstract

As part of the EU Horizon 2020 project REMOURBAN a deep retrofitting intervention has been carried out in seven family houses (from a block of 9 terraced houses). The homes have been refurbished to both reduce their energy demand and to implement a renewable energy fed heating system. This system comprises a photovoltaic (PV) plant, two ground sourced heat pumps (GSHP), a thermal energy storage (TES) and an electric energy storage (EES). The effects of the deep retrofitting and the performance of the heating system have been evaluated by using two different energy modelling software (Design Builder and IDA ICE). Several different models have been developed using the two software platforms to evaluate the energy performances before and after the refurbishing (at this stage the PV and EES are not included in the models). The modelling results highlights a substantial reduction in energy consumption, showing also the substantial negative effect of the two non-retrofitted dwellings on adjacent apartments and the overall performance of the of 9 terraced houses. It is evident that a potential full refurbishment would have brought to a substantial energy savings. The comparison between the different models shows a substantial congruence between the two software platforms.

SDEWES2018.0253

Dynamic Performance of a Solar Urban District Heating System Upon Varying the Characteristics of Seasonal Thermal Energy Storage

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Abstract

A solar district heating system serving a small-scale urban district located in Naples (Italy) is analysed by means of the software TRNSYS over a 5-year period. The plant is based on the utilization of a flat plate solar collectors field connected to a seasonal double U-pipe vertical Borehole Thermal Energy Storage (BTES). A parametric analysis has been performed in order to analyse the performance of the district heating network upon varying the characteristics of the BTES in terms of volume, number of boreholes, thermal conductivity of soil, thermal conductivity of grout, U-pipe spacing and heat carrier fluid. The primary energy consumption, the equivalent CO_2 emissions and the operating costs of the proposed system have been evaluated based on the simulation results and compared with those associated to a conventional heating system assumed as reference in order to assess the potential benefits achievable by optimizing the long-term storage design.

SDEWES2018.0407

Ventilated Greenhouses for Energy Retrofit of Balconies in Condominium Buildings

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Abstract

Energy retrofit of the envelope of condominium buildings may be difficult due to the numerous thermal bridges to be corrected. Among these, thermal bridges due to balconies, common elements in the architecture of Italy and other countries, can be really arduous to correct due to several constraints.

An approach to retrofit of buildings with balconies, alternative to common practice, is analyzed in this paper. It consists in changing a balcony into a ventilated sunspace during the cold season. A solution as simple as transparent PVC sheets installed along the balcony perimeter, and removable in the hot season, can be used to enclose the air volume between two superposed balcony slabs, thus obtaining the sunspace. This is used as a suction pre-chamber for a single-flow ventilation system aimed to ensure the required air changes in the indoor environment. Such an approach can be greatly helpful to control the heat gain to the apartment, which can be increased with respect to a passive sunspace without ventilation and possibly modulated along the day by proper modification of the ventilation flow rate, instead of being governed only by heat diffusion through the external wall. A ventilated sunspace may even make unnecessary thermal insulation of the wall along the balcony and substitution of old windows that faces the balcony.

In this work, a small scale physical model is presented. It will serve to validate dynamic simulation analyses aimed to forecast and optimize the performance of ventilated sunspaces built around balconies.

SDEWES2018.0420

Design Scenarios of the Office Building Facade with Regard to Energy and Environmental Performance

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Abstract

The main issues that need to be considered in designing energy efficient buildings are: reducing energy consumption generated from fossil fuels and reducing environmental pollution. Building envelope is the most responsible structural element of the building in terms of achieving energy balance. Heating, cooling and lighting have largest part in energy consumption in buildings. Researching various facade designs in terms of their contribution to reducing energy consumption is crucial and necessary for each specific case and climate. The estimation of energy performances of different scenarios of the hypothetical models of façade design in case of an office building in Belgrade is presented in the paper. For the analysis, the model of the typical office was created and various facade concepts were applied. Methodological approach entails three steps: design of different facade concepts - models, numerical simulations of the models and comparison of the results. For each hypothetical model, the following scenarios have been created: the basic scenario and scenarios of different facade design solutions related to types of shading devices. Assessment of the scenarios includes consideration of energy demands for heating and cooling, reduction of energy consumption for cooling by implementation of different shading devices and comparison of the results. The results of the simulations show how much the various alternatives of shadings contribute to the reduction of total energy demands, and how much the application of shadings affects the reduction of environmental pollution. The design methodology, as well as the results, can generally be applicable for the design of new and renewal of existing office buildings, both in Belgrade and in similar climatic conditions.

SDEWES2018.0485

Air-Based Photovoltaic Thermal Collectors: Theoretical and Experimental Analysis of a Novel Low-Cost Prototype

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Abstract

In this paper the performance of an innovative low-cost flat-plate PhotoVoltaic Thermal (PVT) collector prototype is investigated. By such hybrid solar panel both electricity and thermal energy can be obtained. As commonly known, the electrical efficiency of PV cells dramatically drops as the operating temperature rises. In order to improve the PV cells efficiency avoiding the overheating, a low-cost heat extraction system was made. Specifically, the cooling system (located under the PV panel, Figure 1a) is composed of two black galvanized steel sheets, properly shaped in order to form seven air channels (Figure 1b). On the top of the structure seven fans were installed in parallel to draw air through suitable air channels. The obtained air thermal energy can be exploited for different building uses. The prototype was built and tested under different operating conditions at the University of Patras (Greece). Then, in order to carry out a deep investigation on the system, a suitable dynamic simulation model was developed for assessing the energy, economic and environmental performance analysis of the system for different weather conditions and building uses. Here, hourly weather data (TMY, IWEC, etc.) can be processed (solar radiation, air temperature and humidity, wind, etc.). The model, implemented in MatLab environment, was validated vs. the above mentioned collected experimental data and a good agreement between the simulation results and the measurements was achieved. In addition, in order to optimize the system design, a specific tool for the system parametric analysis was developed and added to the simulation code. By such tool the effects on the collector performance of the variation of different design and operating parameters (i.e. air channel depth, air mass flow rate, fans speed, etc.) can be carried out.

Finally, in order to investigate the convenience of the presented prototype and the potentiality of the developed simulation tool, a suitable case study is discussed. Here, the PVT collector prototype is coupled to a heat pump for building space heating. Specifically, the air heated in the seven collector channels is supplied to the evaporator of the heat pump, increasing its energy performance and decreasing its operating costs. An office building in three different European weather zones was investigated. Useful design criteria and interesting energy and economic results were obtained.

SDEWES2018.0069

Modelling, Simulation, and Life Cycle Cost Analysis of Fifth-Generation District Heating and Cooling Networks

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Abstract

Fifth generation district heating and cooling (5GDHC) networks are characterised by supply temperatures in the ambient range of 15-25°C, which reduces not only heat losses but allows for the integration of various kinds of low-temperature waste heat sources. The ability of these networks to absorb waste heat that is normally unrecoverable makes them an attractive solution for the future energy supply of urban areas. To enhance the adoption of these networks, this research pursues the development of a software tool to analyse the feasibility of 5GDHC systems in both new and existing districts. The research attempts to answer the question, "which buildings should be connected to a low-temperature hydraulic network given both incremental benefits and costs relative to the scenario of decentralised (dedicated) heating and cooling of each building?" Therefore, all possible network layouts of the buildings are considered, where the heating and cooling demands of each building are met by the 5GHDC network. Simulation results quantify the performance of the 5GDHC network based on various output metrics including primary energy usage, CO_2emissions, and network implementation cost. The buildings in these networks constitute as thermal energy prosumers since the buildings can, at times, provide heat to consumers and, at other times, producers depending on whether a building is in heating or cooling mode. For the heating and cooling load characterisation of the buildings, reduced order models are used, while renewable energy and waste heat sources are included in the network. The focus of the manuscript lies in the development of a hydraulic model for flexible use in the urban energy modelling and the optimisation of the 5GDHC network topology for a given urban district.

SDEWES2018.0070

Reduced Order Building Modeling for Fifth-Generation District Heating and Cooling Networks

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Abstract

The energy performance of buildings served by a fifth-generation district heating and cooling (5GDHC) network, particularly the heat pumps coefficient-of-performance, is a strong function of the inlet temperature, which corresponds to the network supply temperature. A 5GDHC network is characterized by a supply temperature range of 15°C to 25°C, and its hydraulic loop may exhibit both unidirectional and bidirectional flow. Therefore, the grid topology has an impact on the individual inlet temperature of the buildings connected to the loop and a detailed hydraulic simulation of the network is needed to analyse it. Optimizing the network's efficiency and its grid topology leads to an evaluation of many if not all possible network topologies, which is numerically expensive. To be able to analyse and contrast any given district energy system layout, the impact of connecting individual buildings to a 5GDHC network must be quickly evaluated, while allowing for flexibility in deciding which buildings should be connected to the network. Conventionally, each building on the network is represented by a fully defined physics-based building energy model and runs in conjunction with the network simulation. Although this setup allows for running the analysis with flexibility on the building load side, it results in long-running simulations, thus limiting the ability to quickly analyse various network topologies. An alternate approach to determine the building loads is to create a reduced order model (ROM), which would allow the network simulation to request the building loads from a myriad of predefined building types and building characteristics. A parametric analysis using Latin Hypercube Sampling was performed to generate a dataset across various buildings, building characteristics, and locations; this dataset was then used to generate ROMs. Two reduced order modelling techniques were investigated: simple linear models and a more complex machine learning-based method called random forests. This paper focuses on the development of the ROMs and the identification of the best performing model to rapidly estimate the building loads and required energy needed for 5GDHC network optimization.

SDEWES2018.0388

A Computational Tool-Chain for the Automatic Generation of Multiple Reduced-Order Models from CFD Simulations

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Abstract

Classic zonal models of indoor thermal environments, where dynamic local effects of fluid flows are critical are not always suitable. CFD simulations can give accurate solutions but often at high computational cost. Reduced-order models (ROMs), extracted from CFD simulations, can preserve CFD accuracy while having lower run-time computational cost. We propose a methodology and technology framework called CFD-ROM capable of rapidly and automatically generating ROMs from CFD simulations, zones, mass and heat flows, and boundary conditions (BCs).

CFD-ROM consists of the following steps: (1) division of a CFD domain into a ROM consisting of zones of uniform properties using one of many candidate zone generation algorithms, (2) solution of the ROM, (3) visualisation of results, and (4) validation against the original validated CFD solution.

In previous work, the authors determined three candidate zone generation algorithms. These are: (1) Mean Value Segmentation; (2) Classic Watershed; and (3) Coarse Grid Interpolation.

Building upon the previous study by the authors, the key outcome of this work will be the assessment of the method's accuracy and time to solution when generating ROMs for a range of indoor conditions different from the original CFD boundary conditions. This will enable the use of CFD-ROM in a wide range of scenarios in a computationally efficient manner, with minimal input and expertise from the end user.

These outcomes will enable the next development stages of CFD-ROM, which are: (1) to apply the method to a range of CFD simulations to test CFD-ROM's capabilities in different case scenarios, (2) to test the method in critical applications in the field of sustainable smart buildings such as thermal comfort assessment, and (3) to develop a ROM solver in Modelica.

The novel methodology will establish a new formulation to the way in which the high fidelity models are leveraged to generate the ROM. Firstly, the high fidelity models will be utilized to automatically generate the subzones that will comprise the domain of interest. This approach is foreseen to increase the computational cost of the RO model and to reduce the necessary knowledge of the end user. Secondly, the results of the CFD simulations will be further exploited, extracting those parameters that characterise energy and mass exchange between the different subzones. This will further improve the accuracy of the RO models avoiding relying on empirical data and/or correlations.

SDEWES2018.0395

Experimental Evaluation of Soundproofing and Sunreflecting of Nanoceramic Coatings for Building Envelope

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Abstract

The impact of nanoceramic coatings on the sound insulation properties of some basic building boards such as gypsum board with two different thicknesses, OSB and metal sheet has been investigated. The experimental measurements are made using an original Small-scale Soundproof Chamber, created in the Department of Physics of UACEG. The impact of nanoceramic coatings on the sound insulation of the test samples is examined at frequencies of 600 Hz to 8000 Hz due to the specificity of the laboratory setting. The greatest effect of up to 5 dB improvement of the sound insulation and a slight shift of the wave coincidence frequency have been observed in the case of the nanoceramic coating, applied to OSB, which is explained by sealing the pores of the coated material. For the other elements, the effect is negligible. For the same nanoceramic coatings, serving as the last interior or exterior layer of envelope structures, the sun reflectance index and other exploitation characteristics have been studied by applying both field and laboratory methods and specific test set-ups. In the field tests, the applied nanoceramic coating is visually controlled and the surface temperatures are periodically measured. Besides, the relative extensions, the possible occurrence of cracks and the humidity condition are monitored. The condition of the applied coating and the application structure are evaluated. Laboratory tests have been prepared in accordance with the appropriate test methodology. Strength of adhesion with different substrates /concrete and galvanized metal sheet/ and water resistance are measured. The adhesion strength studied is: initial, after immersion in water and after 25 cycles of freezing and thawing at -15 ° C. Infrared emissivity and solar reflectance index in the infrared spectrum have also been measured for interior and exterior versions of the nanoceramic coatings. The best complex results have been recorded for nC 2.0 and nC 2.2 nanoceramic coatings. They can be recommended for practical application. Even with lower performance than thermal nanoceramic coatings (like f.e. Super Thermo Shield), nanoceramic coatings can find market niches due to lower production costs.

SDEWES2018.0398

Fabrication and Performance Evaluation of the Senergy Composite Polymer Solar Water Heating Collectors for Building Integration

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Abstract

The Senergy building integrated solar thermal collector concept aims to reduce costs of solar water heating systems by utilizing innovative nanocomposite polymer materials and offsetting costs of conventional roofing and façade construction components. By incorporating carbon nanotubes (CNT) the physical properties of polymer materials can be augmented leading to improved thermal, optical and mechanical properties. Two working prototypes; one Polycarbonate Graphite Particle collector (PGP) and one Polycarbonate Graphite and Carbon Nano-Tube (PGCNT) collector, have been fabricated using low cost polymer components and in-house fabrication techniques developed at Ulster University. Both collectors used a twinwall polycarbonate sheet to act as the heat transfer fluid channelling element and had solar absorptive surfaces formed of Poly(methyl methacrylate) resin modified with additives. The modular collector design (280 x 1500 x75 mm) combined with low weight (14 kg/m²) allows for easy and scalable integration on to the building skin. The PGP and PGCNT collectors have been tested side by side under Ulster University's solar simulator and their performance compared. Tests were conducted using a standard steady-state solar thermal efficiency measurement procedure under a nominal condition of 750 W/m² irradiance and for water inlet temperatures between 22°C and 45°C. The PGCNT absorber achieved 74.7% maximum collection efficiency compared to 73.2% for the PGP absorber. The heat loss coefficient was 12.8 W/m²K for PGCNT and 12.1 W/m²K for PGP. The measured performances suggest a marginal benefit of adding CNT compared relative to the case of using graphite alone as the absorber pigment. Test results indicate that the current evolution of the Senergy collector design has improved optical and thermal behavioural characteristics than previous versions but suffers from increased heat loss. The nanocomposite absorber achieves performances which are broadly similar to benchmark single glazed flat plate collector solutions with non-selective absorber surfaces.

SDEWES2018.0486

Low-Cost Water-Based Photovoltaic Thermal Collectors: Experimental Investigation and Simulation Model

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Abstract

In this paper, an innovative water-based PhotoVoltaic Thermal (PVT) collector prototype is presented. One of the main novelty of such system is the related economic affordability. This target is obtained through the almost inexpensive elements used for the system construction. Specifically, the PVT collector is composed of a polycrystalline PV module (Figure 1a) coupled to eleven PVC pipes for water heating located in a box under the PV panel (Figure 1b). Th presented system is also suitable for building architectonical integration. It can be used for Domestic Hot Water (DHW) preparation and simultaneously for supplying also electricity to the building. The developed prototype was experimentally tested at the University of Patras under different working and weather conditions.

Subsequently, a suitable dynamic simulation model was developed for assessing the energy, economic and environmental performance analysis of the above described system for different weather conditions and building uses. Here, hourly weather data (TMY, IWEC, etc.) can be processed (solar radiation, air temperature and humidity, wind, etc.). The model, implemented in MatLab environment, was successfully validated vs. the above mentioned collected experimental data (a good agreement of the simulation results vs. the measurements was achieved). In addition, in order to optimize the system design, a specific tool for the system parametric analysis was developed and added to the simulation code. By such tool the effects on the collector performance of the variation of different design and operating parameters (i.e. water pipes diameters, water mass flow rate, collector slope, etc.) can be carried out.

Finally, in order to investigate the convenience of the presented prototype and the potentiality of the developed simulation tool, a suitable case study is discussed. Here, the PVT collector is coupled to a stratified hot water storage tank for supplying DHW to a single-family house located in three different European weather zones: Freiburg, Naples and Almeria. In order to assess the optimal system layout, different design and operating parameters (including the volume of the storage tank) as well as different DHW demand profiles were investigated. Useful design criteria and interesting energy and economic results were obtained.

SDEWES2018.0261

Novel Triangle Flat Plate Solar-Thermal Collector for Facades Integration

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Abstract

A novel type of flat plate solar thermal collector with triangle shape is presented at conceptual level and, based on the simulation results, the collector is built and tested in standard conditions on an indoor testing rig for solar thermal collectors. The collector aims at increased architectural acceptance being thus recommended for façade integration. The size and shape of the collector allows developing solar-thermal arrays able to efficiently cover buildings' facades with variously sized elements. Due to its rather low dimensions, the collector has no internal pipes for the thermal fluid circulation and, instead of these, a central body composed of a cavity below the entire absorber plate is proposed to support this flow. This central body of the triangle collector was virtually prototyped in Solid Works and further transferred to ANSYS in order to identify the optimal solutions that mitigate their deformation, firstly based on equal strength beams and finally on internal connecting elements. Further on, the thickness of the insulation and the air gap thickness between the absorber plate and the glazing were optimized, using the radiative mathematical model. Based on the simulation results, three triangle demonstrator collectors with the aperture area of 0.083 m^2 were manufactured and tested in standard conditions, on an indoor solar simulator, showing nominal conversion efficiencies of 55%, 42% and 35% and low thermal losses coefficients of 0.24, 0.39 and 0.36 °C m^2/ kW for black, green and orange absorber plates respectively.

SDEWES2018.0380

Accurate and User-Friendly Tools for Local Energy Planning

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Abstract

Implementing district energy supply systems, based on integration of local available renewable sources, is one of the fundamental options to achieve relevant outcomes for reducing fossil energy consumption and related emissions in urban contexts. Core of this framework is the analysis and the optimization of the interaction among energy supply and demand profiles, taking into account that, a part biomass and biofuel, renewable sources are intermittent and unpredictable.

Considering a large complex system like a district or a city, an advanced approach is needed to overcome difficulties in modelling correctly real phenomena while maintaining computational transparency, reliability, interoperability and efficiency.

Several computational tools have been developed for district/urban energy planning in the perspective of supporting a real path toward low carbon urban energy systems. A selection of currently available models is presented, providing a comparison aimed to highlight their features concerning goals, calculation methods, applications and final users.

After a desk research of the state of the art of the technical literature, we narrowed the study to seventeen easy access and well documented tools.

We grouped them in four classes based on: type of analysis (type of simulation or optimization), spatial scale of operation, time scale of the outputs, type of energy supply (electricity, heating, cooling) and type of licence (free, open source, commercial).

Our survey confirms a wide range of available tools and of case of application, but, on the other hand, the need of guide lines for a more diffuse use of these tools in widespread planning outside the academic ambit.

In particular, we identified six tools (energyPRO, iHoga, HOMER, EnergyPLAN, SIREN, WebOpt) that enable both energy calculations and outputs visualization on an hourly base and can be considered as viable of widespread use due to user-friendly graphic interface. Therefore, general information and functionalities, structure, graphic interface, required input data and possible outputs of the six tools were described.

A summary of the tools was organised by tables, concerning default considered technologies and main features. Hence, the possible final user can easily access plenty of information on the quality and level of details of the needed data, as well as the related constraints to implement an energy system analysis.

The main value of this study is that the final user is guided in choosing the tool not only based on the related possible outputs and potentialities, but also on available data for a given context, taking into account the main objective of local energy policies and the skills of those who must use the tool.

SDEWES2018.0400

Experimental Study of Naturally Ventilated Ceramic Tile Roof for the Energy Efficiency of Buildings in Mediterranean Weather Conditions

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Abstract

With the increasing cost associated with energy consumption, climate change and the greater awareness of the population to issues related to energy and environmental efficiency, energy conservation in buildings has been encouraged, along with the development of several solutions based on a more sustainable construction. Building cooling is the most challenging issue in the Mediterranean climate. The roof is one of the main elements of the building's opaque envelope, where the choice of materials and the implementation of appropriate passive technologies determine the thermal performance of a building. The present work aims to assess the impact of natural ventilation of a roof cavity on the improvement of the thermal environment of a dwelling house under mediterranean weather conditions. An experimental study was developed in a ceramic tile roof with vented eaves and insulated sub-tile panels, tested under real climatic conditions, in summer time, to study their thermal performance through a long-term experimental evaluation in the different layers/roof elements, such as the air gap. To this purpose, a test cell was designed and built. Measurements of the air velocity inside the air gap, the temperature of the air and the surface temperature of all layers were carried out. Weather conditions were also monitored continuously. Connected with the heat transfer mechanisms, the obtained temperature and air velocity profiles data were analysed and discussed.

SDEWES2018.0409

Energetic and Economic Analysis of a Stand Alone PV System with Hydrogen Storage

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Abstract

In a new distributed and sustainable energy paradigm, based on micro-generation from RES, energy storage, smart grids and electric mobility, hydrogen could represent the energy vector of the future. Renewable energy (solar or wind) could be used as a primary source for the production of electrolytic hydrogen near the end use point, making full use of the local environment energy potential.

As a contribution to the analysis of the gas potential functions, in the work its use as energy vector for storage purposes is analysed, achieved through production of electrolytic hydrogen, storage and reconversion into electricity using fuel cells. In particular, the paper examines the applicability of a stand-alone photovoltaic system equipped with a hydrogen storage system, with reference to a case study aimed at supplying electrical utilities of the Engineering Department building of the Mediterranea University of Reggio Calabria.

The study takes as a basis the features of the instrumentation present at the Energy and Environment Laboratory of the Department (electrolyzer input power, its hourly production, tank capacity, fuel cell power), optimizing the sizing of its elements chain with respect to different electric loads to fulfil.

From an economic point of view, the assessment of economic indicators has confirmed the current non- competitiveness of electrolytic hydrogen use for energy storage, due to the still high investment costs of its production and conversion system; moreover in the study it has been estimated that, in order to have reasonable pay back times, the initial cost should be reduced to about 1/3 of the current value.

SDEWES2018.0494

A New Trnsys Type for Thermosiphon Flat-Plate Solar Thermal Collectors

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Abstract

This paper presents a new TRNSYS Type (called Type 99) for the energy assessment of thermosiphon Flat-Plate solar thermal Collectors (FPCs) for water heating. The accuracy of such new type is higher than the one of the standard type (Type 45) available in the TRNSYS library, since the density and specific heat of water is considered variable with the related temperature. The results of a suitable experimental campaign are also presented for different commercial FPCs system layouts, Figure 1. Specifically, by such measurements the developed Type 99 was successfully validated (a very good agreement between the simulation and experimental results was achieved). By such new Type 99 a suitable Design of Experiment (DoE) analysis was carried out with the aim to assess the design and operating parameters mostly affecting the energy and economic performance of two commercial FPCs. Specifically, collector water pipes diameters, slope, storage tank volume, and thermal insulation thickness were investigated. The analysis was carried out for suitable case studies referred to residential Domestic Hot Water (DHW) production applications and to three different European weather zones (Freiburg, Naples and Larnaca). For such case studies an optimization procedure was also carried out by varying the same design and operating parameters for two different objective functions: best energy behaviour (maximum PES); best economic performance (minimum SPB, maximum NPV). Interesting novel design criteria and encouraging economic results were obtained.

SDEWES2018.0545

Synthesis and Optimal Operation of Smart Microgrids Serving a Cluster of Buildings in a Campus with Centralized and Distributed Hybrid Renewable Energy Systems

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Abstract

Design and optimal operation of energy systems serving clusters of buildings interconnected by energy microgrids is a great scientific opportunity for the engineering community, with many interdisciplinary aspects involved. High energy efficiency can be reached by appropriate and cost-effective integration of locally-available renewable energy sources, centralized polygeneration systems and distributed control of back-up generators and storages. The lack of established design criteria for these hybrid systems and of comprehensive simulation tools are slowing down the spreading of such concept for sustainable urban development. In the paper, the optimization problem is tackled in terms of simulation-based design of the energy system for a typical year of operation. The methodology has been applied to a Campus in Trieste, Italy. We modelled every subsystem involved in energy balances: electrical and thermal energy generators, electrical microgrid, micro-district heating network, wind turbine, photovoltaic and solar thermal panels, thermal storages, heat pumps and chillers, boilers, building envelope thermal response and building heating, cooling, domestic hot water and electrical uses. The level of modelling is sufficiently detailed to consider the main physical and technical aspects involved, but, at the same time, is sufficiently simplified to preserve computational efficiency for the optimization routine. The subsystems are properly coupled, to form a single set of equations, allowing to perform an annual simulation of the whole energy system. The size of the combined heat and power plant has been optimized. We have also found the optimal modulation profile of energy generators (centralized cogeneration unit and distributed heat pumps and boilers) by means of a greedy algorithm. The solution with minimal annual costs is discussed, as well as the capability of heat pumps of conveniently and dynamically shifting thermal loads into electrical loads. This optimal configuration is compared to a less flexible design alternative, not employing distributed heat pumps and having 20% higher annual costs.

SDEWES2018.0231

Analysis of the Performance of Building Integrated Solar Thermal System (Bist) for Domestic Hot Water Production (DHW)

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Abstract

High fraction of the energy demand on high-rise buildings can be provided by renewable energy sources, only when the façade is used for solar energy conversion in addition to the roof.

This is also true for net-zero-energy buildings (NZEB) with a small roof area compared to the floor area, as well as for existing buildings with higher energy demand.

Façade-integrated collectors can fulfil several functions: energy generators for heating water; improve the building's thermal insulation; contribute to lowering heat losses since the absorbers warm up even at low levels of sunlight in winter; structural elements of the façade.

This paper presents a research with key actors from construction industry and energy research in order to convert facades into multifunctional components thanks to their ability to produce energy beside to contribute to lowering heat losses and consequently to reduce the total cost.

TRNSYS software was used to simulate the performance of building integrated solar thermal system (BIST) for DHW applications.

Different system configurations have been analysed, considering the installation of the proposed BIST solution in various Italian climate zone (Ragusa, Catania, Rome and Milan).

The simulations carried out highlighted that 4.0 m^2 of flat solar collectors integrated in facades facing south, are enough to satisfy about 65% of the energy needs for DHW of a single residential unit, in the cities of Ragusa, Catania and Rome and about 44% for Milan. These percentages increase to 77% and 57% if evacuated tube solar collectors are installed.

Based on these results, it is evident that BISTs are very promising systems and architectural components with considerable energy saving prospective and building integration.

SDEWES2018.0393

Occupant Behavior and Comfort Perception Monitoring Integrated to Prediction Models: Impact on Building Energy Performance

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Abstract

Given the rapid scientific progress on active and passive solutions for building energy efficiency, indoor environmental comfort, and renewable energy production, a key variable to be considered to ensure the achievement of near-zero-energy targets is occupant behavior. Occupants' interaction with building systems, indeed, is able to affect field thermal-energy performance. Therefore, occupancy must be considered as variability player when predicting HVAC systems performance, envelope interaction, etc. also affecting renewable exploitation in real buildings. In the last decade, a variety of deterministic and stochastic models, also supported by experimental investigations have been developed and their reliability demonstrated. In this panorama, this paper builds upon previous contributions to analyze the real occupancy of an office building populated by peer occupants. In particular, 5 office rooms have been continuously monitored for 2 years by means of microclimate and energy-need field stations. After showing that the peers do not behave the same and do not equivalently control indoors microclimate parameters (e.g. air temperature, desk illuminance, etc.), internationally acknowledged occupancy models are compared to field-collected data through dynamic simulation. Then, the estimation of building final energy need is calculated by considering both standard and experimental data-based occupancy scenarios. The relative difference is highlighted as a possible indicator about the role of building occupancy profiles in affecting energy need prediction, i.e. HVAC system operation and renewable energy demand. The considered models consist of (i) the UK NCM (National-Calculation-Method for Non-Domestic Buildings), (ii) the ASHRAE Standard 62.1-2007, (iii) the innovative "Occupancy Simulator" developed by LBNL. Additionally, EEG experimental test are used to assess and correlate the subjective emotions of working occupants to external thermal stimuli. The results of building dynamic simulation showed that the final energy need estimation can vary by up to 20% by only selecting the occupancy simulation scheme. Moreover, non-consistent prediction trends are found out while investigating lighting and electric appliances needs. Accordingly, as concerns the human psychological response to the variation of thermal conditions, non-consistent emotional reactions are found among the different tested workers when suddenly altering comfort conditions indoors.

SDEWES2018.0396

Building Integration of Passive and Active Solar Systems in Environmentally-Friendly Prefabricated Housing Units. Introduction of a Taxonomy and Evaluation Methodology

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Abstract

This paper aims to examine the integration of environmental systems and strategies in environmentally-friendly and technologically-advanced off-grid prefabricated housing units. The work is based on a comprehensive precedent and literature review of comparable structures that is subsequently organized in the form of a taxonomy of types of prefabricated assemblies and their inherent potential – from the point of view of both design and construction – to accept the integration of the systems mentioned above. More specifically the main characteristics of existing active and passive technologies are organized according to overarching commonalities amongst the case references investigated. These commonalities are grouped in relation to the holistic approach of the issue of environmental design, which is based on three key aspects: First, on the design of energy efficient structures, which examines active and energy production issues. Second, on the bioclimatic design, which examines active and energy production issues. Third on the ecological approach to design, which refers to the minimization of the ecological footprint of a building, during its life. All cases are addressed in terms of the challenges faced in optimizing the overall design performance so that it leads to an affordable and spatially flexible and site adaptable product and in minimizing the units' lifecycle operational costs with an emphasis on energy consumption. Moreover, the study indicates the potential of prefabricated housing units to exploit solar gains through passive as well as active systems. The current investigation hopefully demonstrates the breadth of the extent of possible typologies related to such prefabricated assemblies as well as the extent of possible integration of active solar systems suitable for such units.

SDEWES2018.0397

Solar Assisted Hybrid Cooling for High Efficient Buildings in Warm Climates: Development and Experimental Testing

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Abstract

The European building sector is currently responsible for about 40% of energy consumption and 36% of CO2 emissions in the continent [1]. Consequently, the EU commission has recently updated the Energy Performance of Building Directive (EPBD), which sets ambitious targets for the increase of the energy efficiency of buildings. To reach such targets, the exploitation of renewable energy sources is mandatory. Different types of poly-generation systems, suitable for the residential sector have been previously proposed, employing for example ad/absorption chillers [2,3] or micro-CHP systems [4–6]. Nonetheless, the experience in the design and installation of these systems is still limited and much effort is needed [7,8]. One solution recently proposed in literature for small residential buildings is hybrid cooling through adsorption-compression chillers, which make use of the advantage of both systems [9].

Within the H2020 project Zeosol, an advanced solar cooling and heating product, using advanced heat exchanger technology and integrating an adsorption chiller and an electric heat pump is being developed. The hybrid system proposed consists of a thermal and an electric unit, suitable for operation under parallel operation. Under this mode, the evaporators of both units are connected to the chilled water circuit and the condensation heat of both is rejected in the ambient by means of a high-efficiency dry-cooler. It is based on a commercial unit produced by Fahrenheit and it has a nominal power of 20 kW, but it was optimized with the target or reaching an ESEER of 15.

A sizing tool was developed in order to simplify the design of the solar cooling system. Input for the sizing tool are the achievable thermal power of solar collectors, as a function of ambient temperature obtained through dynamic simulation, the efficiency of the thermal and electric units and the consumption of auxiliaries as a function of part loads. The methodology implemented can then be easily re-used for the definition of standard sizing procedures.

The hybrid chiller unit, complete with an advanced V-shape dry cooler, is under testing in the laboratories of CNR ITAE. The first tests are aimed at assessing the reliability of operation under different part loads. The first results confirm that the target ESEER of 15 can be reached for an optimal control strategy (the thermal chiller only is operated at 25% and 50% part load while electric unit only is operated for 100% part load conditions).

SDEWES2018.0401

Investigation of Dynamic Thermal Behavior of Novel Biobased PCM for a Variety of Applications

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Abstract

In recent years, the implementation of novel solutions aimed at improving thermal energy storage (TES) capability to both energy technologies and building-integrated systems has gained increasing attention. In particular, the application of phase change materials (PCM) has nowadays gathered worldwide acknowledgment. In this work, the potential of two kinds of bio-based novel PCM having transition temperature around the ambient temperature is assessed by means of thermogravimetric analysis and extensive temperature monitoring during specifically designed hygrothermal cycles. Results from the TGA show the differential degradation of the main components of both the palm oil and the animal fat during the heating phase, where three different decomposition steps could be noticed. The thermal monitoring demonstrated the promising thermal performance of both these materials, which showed phase change temperatures in the range 5-27°C.

SDEWES2018.0447

Design of a Building Integrated Solar Air Heating System Using Ray Tracing Techniques

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Abstract

The aim of this paper is to design and characterise the optical performance of an Asymmetric Compound Parabolic Concentrators solar powered transpired air heater using ray tracing technique implemented in Matlab. The collector has been designed to allow multiple units to be stacked to form an integrated solar wall on the side of agricultural and industrial buildings. The weight and shape of the collector has been included in the design so it only required two people to install each collector. The collector design has no overhang when multiple units are stacked on the top of each other and each collector accepts all direct solar radiation during the summer period for eight hours per day. The optical analysis considered the effect of the design variables such as length, width, aperture size, concentration ratio, parabolic shape, and glazing inclination angle. The 3D ray tracing model results are used to analyse the effect of collector width and length and the corresponding end plate size has on the overall pattern of concentrated radiation received on the transpired absorber plate.

Special session: Polygeneration: a novel paradigm for an efficient and sustainable use of energy resources

In conventional systems, energy conversion is typically performed by different devices separately producing electricity, heat, cooling energy and/or other products. This approach has been used for a long time, driven by the requirements for system simplicity and reliability and supported by the large availability and low prices of fossil fuels. However, in the past decades this scenario has been rapidly changing due to the increasing concerns about depletion of fossil fuels resources and greenhouse gases emissions. In this framework, new energy conversion paradigms must be developed, aiming at improving systems efficiency and sustainability, simultaneously reducing their environmental impacts. As a consequence, energy conversion devices can be integrated in single optimized systems, maximizing the utilization of energy inputs (either from renewable or fossil sources) and limiting any possible waste energies. Such a target may be achieved by adopting Polygeneration systems. In fact, polygeneration is the combined production of multiple types of energy (e.g. electricity, heat and cool) and material products (e.g., desalted water, hydrogen, glycerine, ammonia,etc.). Polygeneration systems can be based on both renewable (solar, wind, hydro, biomass and geothermal) and fossil fuels-based (reciprocating engines, combined cycles, etc.) technologies, in different combinations. At meantime, in order to increase their penetration potential, polygeneration systems must accurately face with the dynamic trends of user energy and products demands and minimize the mismatch between instantaneous production and loads. This is extremely important in order to favor the growth of the so called Distribute Generation, which is unanimously recognized to achieve a number of benefits, in terms of increased efficiency, reduction of transportation losses and maximization of use of local resources. To this scope, polygeneration systems can be equipped with suitable thermal (sensible, latent and chemical) and electrical storage systems (battery, supercapacitors, super wheel, CAES, mini-hydro) and specific control systems aiming at optimizing the utilization of energy sources and/or products in order to maximize the economic profitability. Moreover, the connection of polygeneration system with energy networks (electricity, gas, district heating / cooling) is crucial for the development of this technology.

In this framework, this Special Session aims at collecting recent studies and contributions focused on polygeneration systems. Manuscripts focused on crucial aspects like systems modeling, control strategies and experimental analysis at whole-system, single-component levels and integration of polygeneration systems with energy networks are welcomed. Also, studies including thermoeconomic analyses and single- or multi-objective optimizations are well targeted for the Session.

Session organizers:

Prof. Francesco Calise, University of Naples Federico II, Naples, Italy

Prof. Laura Vanoli, University of Cassino and Southern Lazio, Cassino, Italy

Prof. Antonio Piacentino, University of Palermo, Palermo, Italy

Francesco Calise - Francesco Calise was born in 1978 and graduated cum laude in mechanical engineering from the University of Naples Federico II, Italy in 2002. He obtained the Ph.D. degree in Mechanical and Thermal Engineering in 2006. From 2006 to 2014, he is a Researcher and Assistant Professor of applied thermodynamics at the University of Naples Federico II. In 2014 he has been entitled as Associate Professor at the University of Naples Federico II. His research activity has been mainly focused on the following topics: fuel cells, advanced optimization techniques, solar thermal systems, concentrating photovoltaic/thermal photovoltaic systems, energy saving in buildings, solar heating and cooling, Organic Rankine Cycles, geothermal energy, dynamic simulations of energy systems, renewable Polygeneration systems and many others. He was invited lecturer for some courses or Conferences (UK and Finland). He teaches several courses of energy management and applied thermodynamics at the University of Naples Federico II for BsC, MS and PhD students. He was a supervisor of several Ph.D. degree theses. He is a reviewer of about 30 international Journals. He was involved in several Research Projects funded by EU and Italian Government. He is Associate Editor of 4 International Journals. He was a Conference Chair and/or member of Scientific Committee in several session of International Conferences. His Scopus indexes (August 2016) are: Documents: 69; Citations: 1205; H-Index:20

Laura Vanoli - Laura Vanoli is full professor of Applied Thermodynamics at the Civil and Mechanical Engineering Department of University of Cassino and Lazio Meridionale. In 1997 she obtained her five years master degree with honours in Mechanical Engineering from the University of Cassino. In 1999 she gained her Ph.D. in Industrial Engineering at the same University. From November 1999 to October 2003 she was assistant professor at the Department of Industrial Engineering at the University of Cassino. From November 2003 to January 2005 she worked as assistant professor at the Department of Food Science of the University of Naples Federico II. In September 2004, she was visiting researcher at the Energy Management Institute of Virginia Polytechic Institute and State University (USA). From January 2005 to October 2008 has been working as associate professor at the Department of Food Science of the University of Naples Federico II. From November 2008 to December 2016 she was associate professor at Engineering Department of the University of Naples Parthenope. Her research of interests cover: thermodynamic and thermo-economic analysis of advanced energy systems, energy saving, renewable energy sources, thermo-fluid-dynamic measurement. Over the last ten years she has been working on simulation optimization and exergy analysis of hybrid SOFC-gas turbine power systems, dynamic simulation and thermoeconomic analysis of polygeneration systems based on renewable technologies and sources. On these subjects, she has written more than 90 scientific papers, mostly published in International Journals and Proceedings of International Conferences. She has coordinated and participated in several research projects funded by the Italian Ministry for Research (MIUR), and private companies. She thought several modules at the Universities of Cassino Napoli Federico II and Napoli Parthenope: Energetics for Master of Science degree in Mechanical Engineering, Applied thermodynamics for BA degree in Food technology, Applied thermodynamics for BA degree in Industrial Enginering, Exergy analysis for BA degree in Management Engineering, Energy Management for Master degree in Management Engineering. Since 2015 she has been adjunct researcher at the Engines Institute of the Italian National Research Council.

Antonio Piacentino - Antonio Piacentino is associate professor at Dpt. of Energy, ICT and Mathematical Models, University of Palermo. He currently teaches Energy Management and, in the past, has held graduation courses on Thermodynamics and Heat Transfer. He has served as a supervisor for two PhD thesis and for more than 60 Master's and Bachelor's theses. His main research activities have been focused on cogeneration and trigeneration applications in buildings, thermoeconomic cost accounting and diagnosis of energy systems, energetic and exergetic analysis of thermal desalination systems, process integration and pinch analysis, with some research activities also regarding proton exchange membrane fuel cells. Prof. Piacentino has been involved in two European projects concerning cogeneration and co-financed in the framework of EU SAVE programme, and in one Project of Research of National Interest on a similar topic financed by Italian Ministry of University. He is currently Head of a Research Line within a project financed in the framework of the National Operative Programme "Research and Competitiveness". He has authored or co-authored more than 80 papers, with more than 30 published on scientific and technical journals indexed by high-level databases. He serves as an associate editor for several scientific journals and as a reviewer for a number of journals in the fields of thermodynamics, heat transfer, energetics and desalination. Also, Prof. Piacentino is member of several national and international asociations, like the European Desalination Society, the Italian Union of Thermofluid dynamics and the Italian Association of "Fisica Tecnica".

Invited submissions

SDEWES2018.0164

Comparison of CHP Systems for the Paper Industry in the Context of High Efficiency Cogeneration

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Abstract

In January 2011, the incentive scheme for cogeneration power plants changed radically by the introduction of high-efficiency cogeneration (HEC) in Europe. As a consequence of the establishment of this directive, the techno-economic feasibility of new cogeneration plants in different areas of application (industry, service, residential etc.) and their optimal operation have been deeply modified. The previous legislation considered the entire electricity production as cogeneration electricity if two parameters, primary energy saving and thermal limit, evaluated on an annual level, exceeded specific limit values. This old incentive scheme made the sizing of Italian cogeneration power plants be focused on the maximum electricity output. According to the new incentive scheme, however, if cogeneration power plants do not reach an established value of overall efficiency, it is necessary to split them in a CHP portion and a non-CHP portion and the incentives are proportional to the energy quantities pertaining to CHP portion only. This situation implies that cogeneration power plants designed on the basis of thermal demand are more rewarded, as opposed to what happened in the past.

The main area of application of CHP systems is industry and, among the various sectors, paper industry appears the most suited to be matched with cogeneration. Since the choice of the most appropriate technology and the sizing are essential in industry, the present study considers a particular industrial reality and aims at comparing different cogeneration solutions to be coupled to it. This will be accomplished thanks to the definition and analysis of energy, environmental and economic performance parameters, always bearing in mind the high-efficiency cogeneration framework and making use of GateCycle software as the main calculation tool.

SDEWES2018.0370

Technoeconomic Assessment of a PVT-Based Solar Combined Cooling Heating and Power (S-CCHP) System for the University Campus of Bari

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Abstract

This research considers the integration of novel hybrid photovoltaic-thermal (PVT) collectors based on a flat-box structure developed in previous work, with an absorption chiller (AbCH) unit (single-stage LiBr-H_2O) for the combined provision of cooling, heating and power (S-CCHP system) at the University Campus of Bari (Italy). The Campus has an electricity demand of about 10 GWh/year. The thermal demand is covered by 390,000 Nm^3 of natural gas/year, with a heated area of 127,300 m^2 and a volume of 495,300 m^3 for the 12 university buildings. The demand for DHW is negligible, and all the thermal demand is used for SH, with the temperature of hot water at 80 °C. In the proposed S-CCHP system, the thermal output of the PVT collectors is connected, through a water storage tank, to the current gas-fired boilers and is used to preheat the water to satisfy the SH demand, reducing the natural gas consumption. In cooling mode, the AbCH unit is fed by the thermal output of the PVT collectors (through the backup gas-fired boilers when required) in order to provide cooling. The electrical output of the PVT collectors is used throughout the year to cover the Campus's electricity demand.

The aim of this work is to analyse the technoeconomic performance of the proposed S-CCHP system throughout a year, using a TRNSYS model that features the polymeric flat-box PVT collector coupled via a thermal store to an AbCH unit (electrical+thermal S-CCHP system). The thermal and electrical demands of the University Campus of Bari are used as inputs to the model. Hourly transient simulations of the complete system considering real weather data and reasonable areas for PVT collector installation (up to the maximum available roof-space') are performed over a year. Current electricity and gas prices are considered to estimate the annual cost savings which, together with the system's investment cost, allow an estimation of the payback time (PBT) of the various alternatives. The existing scenario of gas-fired boilers operated within an Energy Service Contract by an ESCO for the provision of SH is considered to estimate the avoided costs of thermal energy with the proposed S-CCHP system. The results are then compared to a fully-electrical S-CCHP system consisting of a set of PV panels that match the electricity demand of the Campus (including the electricity required to run the current HVAC system for air-conditioning).

SDEWES2018.0387

Hybrid Renewable Energy Systems: Implications Between Model Predictive Control and Thermal Utilisation

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Abstract

The concept of distributed generation, that is based on Hybrid Systems with production from renewable sources and storage components, has increased the focus on the operation of LV (Low Voltage) electricity distribution networks. However, at the level of LV networks the high variability of load and supply profiles makes the matching process quite challenging.

Energy Management System (EMS) based on Model Predictive Control (MPC) strategies have demonstrated great capabilities in terms of matching between load and supply, enhancing the utilization of renewable sources. However, the performance of the EMS depends on the robustness of the forecast the day ahead. In order to improve these predictions a novel approach based on a correlation clustering strategy has been implemented in a MPC-based EMS to correct the forecasts thus improving the performance and reliability of the EMS control actions. In case of loads characterized by both electric and thermal demand, system sizing toward performance and costs may give different leverage effects than in the simple electric load case.

Results obtained so far show an improvement in the RES self-consumption and a better utilization of the Energy Storage System (ESS), highlighting the capability of the method to reduce the Hybrid Renewable System (HRES) subcomponents size and thus the overall system costs.

SDEWES2018.0443

Preliminary Simulation Study and Heat Integration of a Highly Intensified and Flexible Process for Bio-DME and Electricity Production

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Abstract

We present the preliminary process modelling study and heat integration optimization for a novel highly intensified and flexible process for the co-production of bio-DME and electricity from biomass. The process combines two “sorption-enhanced” reactors: one holds a flexible sorption enhanced gasification process whilst the other undergoes a novel sorption enhanced DME synthesis. The novel system is being developed in the framework of the H2020 EU project FLEDGED.

The preliminary process simulation is based on simplified (first-principle) models of the main process units while the heat integration optimization is performed with a systematic energy targeting methodology. The DME off-gas can be used in a gas turbine or in an internal combustion engine with minor differences in efficiency while the process waste heat can be efficiently recovered by a multiple-pressure-level heat recovery steam cycle. According to the results, the plant can achieve a biomass-to-DME conversion efficiency of 31.14 % (LHV basis) and a biomass-to-electricity conversion efficiency of 19.3 %.

SDEWES2018.0449

Second Law Analysis of Cogeneration Power Combined Cycle and Med Water Desalination Plant

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Abstract

One of the key challenges facing energy researchers and professionals is to minimize environmental impacts that emitted from energy systems. In the current study, an exergy analysis is presented for a cogeneration power and water desalination plant using real operational data. The power side is consisting of a very advanced combined cycle power plant with triple pressure reheat heat recovery steam generator, while the desalination side is a conventional multi-effect plant. Specialized software was used to develop the proposed system model and was validated with reference to manufacturer-supplied data as well as previously published data. A real mixture principle approach has been used to model saline water using latest thermo-physical properties available in the literature. The impact of varying the number of effects, loads, pressure ratios, temperatures of feed water, cooling and steam were examined on the proposed plant performance. The exergy destruction and exergy loss are shown to be 41.7% and 6.7 %, of the total fuel input, respectively at international standards organization condition. Despite the low exergy destruction of desalination unit compared to combined cycle power plant components, it is considered high relative to fuel exergy input. Increasing the number of effects improves overall plant efficiency and multi-effect desalination plant capacity as well, due to higher utilization of energy input in the desalination unit.

SDEWES2018.0522

Biofuel-Based Poligeneration Energy System for Electricity, Heat and Mobility Demands: Plant Design and Energy Streams Management

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Abstract

Polygeneration systems represent a novel concept for the transition to sustainable low-carbon future energy systems. The plants based on this concept can use multiple energy sources (renewable and non-renewable) providing multiple energy services (heating, cooling, electricity) and other products such as fuels or water. In this way, a substantial increase in overall efficiency is achieved, and thus, indirectly, a reduction of pollution and greenhouse gas emissions.

In this paper the design of a biomass-based polygeneration system generating electricity heat and hydrogen for small refilling stations is proposed. The polygeneration system is fed by biogas, obtained from an anaerobic digester where the biomass conversion is made. It consists of i) a biogas processing unit, based on autothermal reforming technology, in which a hydrogen-rich gas is generated, ii) a power unit based on SOFC technology, iii) a hydrogen separation unit based on membrane technology and iv) a hydrogen compression and storage unit based on ionic compressor technology. The analysis has been carried out by using a numerical approach.

The system behavior has been investigated by varying the SOFC electric load from 100% to 30% (the minimum load that permits to sustain the electric power consumption of the hydrogen separation and compression units). The calculated system performance in terms of overall efficiency range from 67.5% (60% SOFC load) to 71.4% (30% SOFC load). The energy saving with respect to the separate production of electricity, heat and hydrogen ranges from 6% to 26%.

SDEWES2018.0038

Comparison of Centralized and Distributed Energy Conversion Systems Meeting Electric, Thermal and Cooling Loads of a Multi-Storey/Multi-Users Building

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Abstract

Buildings are responsible for consuming up to 40% of the total energy in European Countries, with a related emission of 40% of total greenhouse gas emissions. A percentage of 65% of residential sector requirements is for space heating and cooling demand. This scenario led to a great interest in developing energy efficiency policies to reduce the primary energy demand and the greenhouse gas emissions, as required by climate and energy targets of European Union within 2030. In this paper three different air conditioning systems for space heating and cooling of a building located in Naples, are investigated. The multi-storey building has six floors, the first two are intended for office use, while the remaining are residential apartments. In the first solution the building space heating demand is satisfied by a centralised natural gas boiler delivering up to 65 kW of thermal power, while the cooling load is met by an electric chiller with a nominal cooling power of 59.8 kW. Both energy conversion systems interact with a thermal energy storage tank. The second analysed plant is based on distributed energy conversion systems. It consists of twelve boilers, each one able to delivers up to 25 kW, and twelve electric chillers, each one with a nominal cooling power of 6.14 kW. In both cases the building electric energy demand is satisfied by the external electric grid. The third option consists of a trigeneration plant based on a cogeneration system coupled with an absorption chiller. This centralized system meets base electric, thermal and cooling loads of the building, while for peak loads the electric grid, a natural gas fuelled boiler and an electric chiller are considered respectively. The aim of this paper is to compare the energy and environmental performance of the centralised systems with those achieved by the distributed energy conversion systems, by means of dynamic simulations carried out in TRNSYS 17 software. The results show that the best energy performance are achieved by the decentralised system (Case#1), with a primary energy saving of 9.24% with respect centralized conventional system (Case#2). On the other hand the centralized plant based on cogeneration technology (Case#3) reaches the greatest CO_2 equivalent avoided emission (17.23%) in comparison with Case#2 configuration.

SDEWES2018.0332

Assessment of Different Renewable Energy Generation Scenarios Using 3D Urban Modelling Tools

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Abstract

In the paper, a method was developed to automatically generate energy supply scenarios for cities based on 3D building modelling of the heat demand. In addition, the roof geometry of every individual building was used to model photovoltaic energy generation. From the heat demand analysis hourly load profiles were derived and used to dimension two types of supply systems, namely a heat pump (HP) and a cogeneration (combined heat and power - CHP) system with storage and distribution system.

For the HP scenario, it could be shown that the case study city´s heat demand could be covered by a monovalent, low temperature system with storage, but that the PV only contributed 15% to the HP electricity requirement. For the CHP scenario, only 61% of the heat demand could be covered by the CHP, as it was designed for a minimum of 4,000 operating hours. Both the PV and the CHP electricity are fully injected into the grid. As a result, the primary energy comparison of both systems strongly depends on the chosen primary energy factors (PEF): with given German regulations the CHP system performs better than the HP system, as the grid injected electricity has a PEF of 2.8. In the future with increasingly lower PEFs of electricity, the situation reverses and HPs perform better, especially if the CHP continues to use natural gas. Only if biogas or power to gas (P2G) from renewables is used for the CHP, the primary energy balance of the CHP system can compete with the HP system.

SDEWES2018.0342

Assessment of a Sludge Dryer Coupled with an ORC System Powered by Geothermal Energy

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Abstract

Wastewater treatment has been recognized to be one of the most energy-intensive processes in the water sector. Several processes, required for wastewater purification, present a high electricity demand, whereas drying for sludge processing is characterized by a high thermal demand. To supply such energy demands, the use of renewable energy sources has been strongly recommended, especially in small islands, where the lack of connections with mainland and the environmental restrictions limit the use of conventional fuels and technologies. In this work, geothermal energy is proposed to supply electric energy demand of a wastewater treatment plant and to dry the sludge produced. The case study considered is the wastewater treatment plant of a district of Ischia, a small island in southern Italy, which presents a geothermal source at low-medium enthalpy. Electric energy is produced through an ORC system and the desiccant flow for the dryer is heated by the geothermal fluid in an air-water heat exchanger.

The thermodynamic analysis of the system is carried out through the software Aspen PLUS. Through the energy results, the profitability of the proposed layout is measured by several economic and environmental indicators. Finally, an exergy analysis of the system and its main components is presented.

The developed layout reduces the sludge to be disposed by 395 ton/y and produces 590 MWh/y of electrical energy. Despite the high investment, the revenues deriving from the avoided sludge disposal and the electricity production, makes the system convenient, with a Simple PayBack, equal to 5.10 y. Moreover the integrated layout allows to save 438 tons CO_2/y.

SDEWES2018.0390

Energy Analysis and Bim: the Case Study of the Maritime Station of Napoli in Southern Italy

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Abstract

In Italy, the relationship between Building Information Modeling (BIM) and sustainability is an emerging concept that is becoming more and more interesting in the construction industry. This paper proves the effectiveness of BIM as a technique to analyse the energy performance of existing buildings. BIM technology has been used to carry out energy retrofitting of the Maritime Station of Napoli, in order to analyse the possibility to employ geothermal heat pumps, coupled with geothermal probes recovered from artificial ground freezing operations, in accordance with the principles of the circular economy.

The literature provides different methods for energy modeling of buildings, with the aim of evaluating the performance improvement induced by energy retrofitting. These methods usually imply the use of dynamic simulation softwares, whose graphical interfaces are often not efficient and effective as the popular CAD modeling tools. In particular, BIM environment could help to speed up certification procedures and, thanks to software's interoperability, to define a new methodology for the design stage of energy efficiency interventions.

Firstly, the present study focuses on the analysis of the energy needs of the Maritime Station of Napoli in southern Italy, located in the Angevin wharf and hosting the port terminal. The station, built in 1936, has two factory bodies that house two identical atria. Below these structures, there is a gap, initially arranged as a parking area for trains and currently dismissed. Recently, these spaces have been restored and reorganized, respecting the original architectural lines. In particular, the authors have focused their attention on energy retrofitting of the air conditioning system within the station.

Secondly, the authors have evaluated the potential improvement of the energy performance of the Maritime Station of Napoli deriving from the coupling of the existing air conditioning system with the freezing probes used for the realization of two underground tunnels for the new metro line in Naples. The probes can be recovered after the intervention and employed as geothermal heat exchangers. The analysis has been conducted through the following methodological steps: i) construction of the building model in BIM environment; ii) transfer of the BIM model in DesignBuilder; iii) dynamic simulation of the building; iv) evaluation of the energy savings deriving by the introduction of the heat pumps coupled with the recovered freezing probes

SDEWES2018.0510

Energetic Performance Assessment of Different Chp-Chcp Configurations of a 15 KW Micro-CHP Plant Through 1D Thermo-Fluid Dynamic Simulation

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Abstract

The exploitation of renewable energy sources and the widespread adoption of primary energy saving techniques have been recognized as key solutions to face climate changes. These solutions are pushing the transition from a centralized power generation system to a distributed polygeneration system which is suitable to meet simultaneous heating, cooling and electricity demand. However, small scale polygeneration plants do not ensure effective primary energy and cost savings without a proper sizing and operation of the plant. Furthermore, a customized configuration of the waste heat recovery system adopted for cogeneration purposes can be equally important. Therefore, starting from the experimental data concerning a 15 kW micro-CHP plant previously designed and prototyped, the paper addresses the energetic characterization of different CHP-CHCP configurations of the same plant through 1D thermo-fluid dynamic simulation. In particular, as the achievable primary energy saving depends on the thermal power recovered and actually exploited, and so on the temperature level which characterizes the user's thermal demand, three different configurations of the waste heat recovery system were analyzed and the plant energetic performance estimated. Each configuration, delivering thermal power at different temperature level, could be useful to meet thermal and cooling demand from different user. This paper also provides useful results for the design of CHP systems which are capable to ensure a reasonable matching between the temperature level required by the user and that provided by the plant. In this way, primary energy savings are more easily achievable even when a micro-CHP application is considered.

SDEWES2018.0614

Modelling of mCHP Unit as a Smart Generation System for the Electric Grid Integration

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Abstract

Nowadays in Poland, ca. 80% of the electricity is generated in the central coal-fired power plants and sent through the old electric grids to the distant customers. In addition, most households have heating systems based on high emission coal-fired boilers which are low efficient. One of the possibilities to solve these problems is wide application of the modern high efficient mCHPs powered by Renewable Energy Sources (RES). It decreases the load in the electric grids and reduces the air pollution from fossil fuels. In the article the method and algorithm for control strategy of mCHP operation for reducing the power consumption peaks (peak shaving) is proposed and analyzed. The two scenarios of the mCHP's operation, with and without the control strategy, are introduced. The profiles of power and heat demand was created and used to calculate the power and heat production in a biomass mCHP in a sample house. For calculation, a pellets boiler with a thermal power of 13 kW_{th} and Stirling engine with a 1 kW_{e} of power, manufactured by OKOFEN, was used. These results were used to analyze two scenarios of the control strategy. In the first scenario, standard mCHP control depending on the water temperature in the heat storage tank was assumed. In the second scenario, the operation time of the mCHP depends on the duration of the morning and evening peaks. In this study, the operation of mCHP was simulated in EnergyPro software. Application of this control strategy to the decentralized mCHPs allows very effective "peak shaving" in the local power grid. It also allows better reduction of the load of the conventional grids, substations and other equipment. The surplus of the heat produced in the domestic mCHP is stored in the tank and can be used for heating. The results of calculation with the new algorithm, shows that the electricity generated in the mCHP covers the total demand for power during morning peak and reduce the evening peak up to 62%. The efficiency of the power peaks reduction strongly depends on the demand for heating. In the transition periods, the mCHP unit with applied control strategy can reduce the morning peak up to 75% and the evening peak up to 62%. The influence of the heat storage size on the efficiency of the peaks reduction was analyzed. Reduced load in the power grid and better coverage of the own electricity needs are also observed.

Special session: Energy efficiency in Cultural Heritage Buildings and Preserved Landscape

Upgrade of energy efficiency in existing buildings is an essential objective of every energy policy. Cultural Heritage buildings consist of a vast and widespread amount of the entire building stock in many urban realities. At the same time, the goals of sustainable development and energy efficiency may become an opportunity to strengthen and to make more specific the objectives of architectural and landscape preservation. The renovation of these buildings requires targeted technical solutions and each new intervention, including the one related to energy efficiency, has to maintain the cultural and natural values and even more achieve suitable landscape integration within the urban context. Therefore, defining renovation strategies aimed at improving the energy performances of the protected cultural and natural heritage is genuinely complicated. The implementation of energy measures can imply modifying the building envelope or a natural context, installing new systems, including renewables, while often neither ready to use solutions nor mandatory methodologies are provided to support designers' choices, thus stimulating the search of new forms and levels of compatibility. The objective of this special session is to identify and address critical aspects related to this subject, collecting significant experiences for enabling advancement to the knowledge in the field. That includes different retrofit experiences in different historical building typology or in different preserved context, like small islands or particular historical centres or villages, to efficiently manage natural resources about territorial vocations and landscape compatibility.

Session organizers:

Prof. Giuseppina Ciulla, Scuola Politecnica Università di Palermo, Palermo, Italy

Prof. Simone Ferrari, POLITECNICO DI MILANO, DIPARTIMENTO ABC, Milano, Italy

Giuseppina Ciulla - Giuseppina Ciulla is a Senior researcher at the University of Palermo - DEIM (Italy). Ph.D in Energy (2010). Her research activities were primarily aimed to study: thermal dynamic simulation of buildings, thermo-physics and energy certification of buildings, use of renewable energy sources in urban areas. From 2009 she has collaborated in teaching in: Environmental Technical Physics; Environmental Technical Control, Renewable Energy Source, Safety of technical Plants; Solar Energy Systems. Now she is working in the teaching activities of the DEIM in Energy certification of buildings and Technical Physics. She was an active member of several national and international research groups (Net Zero Energy Buildings –IEA Task 40; and Compact Thermal Energy Storage-Task42-IEA). Recently, she has participated in activities related to: the project of the European LIFE project ENV/IT/000594 "SUN & WIND" which deals with sustainable construction; the project of the FACTOR 20:Forwarding demonstrative ACTions On a Regional and local scale to reach EU targets of the European Plan"20/20/20" - LIFE08 ENV/IT/000430 and the project of UPI "Unione delle Province Italiane" concerning the assessment of energy performance of non-residential buildings in southern Italy. She is author of more than 40 international papers published in national and international journals and conferences. Other scientific interest are: processing of meteorological data, monitoring of solar systems, analysis of energy performance of PV systems, building simulation models and investigations of alternative methods to solve the building energy balance with the application of Artificial Intelligence or a-dimensional approach.

Simone Ferrari - Simone Ferrari in 1994 started collaborating in teaching and research activities at Politecnico di Milano in the fields of energy savings, advanced technologies and renewables for the built environment. From 1998 to 2001, in particular, he worked as a Research Fellow on the development of tools for the configuration of urban building regulations and standards towards reducing CO2 emissions. From 1996 to 2001, he also was consultant for the research institute Ambiente Italia and successfully completed several studies on the energy planning at urban scale and energy audits for buildings' retrofit. Since 2001, he is Assistant Professor of Applied Environmental Physics. He has guided several degree theses, for the first and second university levels, and has supervised 6 PhD theses, having joined the faculty boards of the PhD programmes "Technology and Design of Environmental Quality at the building and urban scale", "Technology and Design for the Built Environment" and "Design and Technology for the Enhancement of Cultural Heritage". In these frames, he also has taught the post-graduate courses "Energy in building and systems", "Strategies for energy recovery of the built environment" and "Energy efficiency in architectural design". Simone Ferrari has participated in over thirty national and international research projects, including the Annexes 46 "EnERGo - Holistic Assessment Tool-kit on Energy Efficient Retrofit Measures for Government Buildings" and 56 "Cost-Effective Energy and Carbon Emissions Optimization in Building Renovation" of the International Energy Agency's Energy in Buildings and Communities programme, and is participating in the recently started Annex 75 "Cost-Effective Building Renovation at District Level Combining Energy Efficiency & Renewables". He is author of a hundred scientific publications, half of which in the international arena, including the book "Building Energy Performance Assessment in Southern Europe" - SpringerBriefs in Applied Sciences and Technology (2016).

Invited submissions

SDEWES2018.0034

User Activity Simulation for Residential Buildings

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Abstract

User activities play a crucial role in the energy demand of residential buildings and will become increasingly important for smart homes with low energy consumption and low emissions. However, it is often difficult to obtain detailed user activity data and associated energy consumption. User behavior patterns are closely related to energy consumption for modeling or simulation. This paper presents a probabilistic activity model that builds from time-use survey data and creates the data generator that can generate realistic activity sequences for individuals and households. The experimental results demonstrate the effectiveness of the proposed model.

In this paper, we focus on the user activity simulation of residential buildings. First, we establish a probabilistic model calibrated by the real-world time-use data with detailed activity information of residents. Then, based on the activity model, we develop a data generator to generate individual and multi-family activity sequences that include eight possible states. In the end, we evaluate the models using statistical methods, and compare with the real-world time-use survey data.

SDEWES2018.0192

Evaluation of Natural Interior Insulation Materials: a Case Study in Bamberg

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Abstract

Historic buildings are the defining elements of European city centres but also responsible for a considerable share of greenhouse gas emissions. In order to decrease their energy demand it is important to reduce the transmittance of the thermal envelopes without damaging the monumental integrity of the façades. Interior insulation has proven to be a reliable solution. However, a detailed planning including dynamic hygrothermal simulations is needed to guarantee that the characteristics of the individual historic construction and the local climate are well considered. This paper analyses the conservation and rehabilitation of a residential building located in the centre of Bamberg, a listed UNESCO World Heritage city in Germany. The envelope is composed of a traditional brick massive wall on the ground floor and a half-timbered structure filled with bricks on its first floor. A performance-based evaluation will compare the energy and hygrothermal efficiency of six natural-based insulation materials: bricks with perlite filling, wood fibre, cellulose, cork, mineral foam and calcium silicate. The hygrothermal risks are investigated in the most critical points of the construction, while a specific analysis is made to avoid the decay of the wooden part of the section. Moreover, as previous research had shown the importance of the material choice in the final energy balance, a life-cycle assessment (LCA) is performed to investigate the environmental impact of the selected material. Results show the importance of adopting a holistic evaluation method, which could take into account hygrothermal, energy and full life-cycle assessments.

SDEWES2018.0239

Energy Retrofit of Public Buildings and Multiple Criteria Decision Aiding: the Application of the Electre Tri-Nc Model to a Decision Process Under Architectural or Landscape Constraints

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Abstract

This study investigates the use of Multiple Criteria Decision Aiding (MCDA) for supporting the allocation of economic resources in public decision problems regarding financing measures of energy retrofit in public buildings that are located in preserved contexts. In particular, the paper proposes the application of the ELECTRE TRI-nC method for sorting several alternative retrofitting measures in a real decision problem concerning 38 public buildings located in Southern Italy. A set of 210 potential energy retrofitting measures was evaluated considering three types of criteria, namely energy efficiency, financial feasibility, and architectural/landscape constraints, and assuming two scenarios, a baseline condition and a situation with public incentives for funding the operation. An experts' panel was involved in the research for helping the development of the evaluation process.

SDEWES2018.0259

Energy Retrofit of Rural Protected Buildings. the Case of a New Agri-Food Hub in a Peripheral Context in Milan

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Abstract

The research origins in the framework of "UIA OpenAgri – New skills for new Jobs in Peri-urban Agricolture", a European project of sustainable and integrated urban development that involves 16 partners leaded by Comune di Milano. The project is devoted to the creation of an innovative agri-food hub, combining smart agricultural solutions and the implementation of circular economy.

The present research focuses on the renovation of two historic buildings, where some of the partner's activities will be hosted. Two types of constraints were encountered: the buildings are protected because historic heritage and the area belongs to local landscape parks.

First aim of our study is to support and address the energy retrofit project of the buildings toward energy efficiency and integration of the local renewable potential. In this framework, we started with the analysis of the state of conservation of the buildings and with a first hypothesis of energy efficiency interventions by means of dynamic simulation: retrofit of the windows and of the roof, insulation of the opaque envelope from the external side. We adopted IESVE tool for simulating the thermal behaviour of the buildings (with a total surface of 1699 m^2 and 10 thermal zones). Many assumptions were defined in order to design properly thermal zones, internal load for particular use destinations such as food laboratories, etc. Further, we supposed to design systems and plants basing on local available renewable sources (heat pump connected to local available wastewater as source of heat and BiPV systems).

During the process, due to the mentioned constraints and the final opinion by the superintendence, we were forced to consider an alternative retrofit solution with insulation of the opaque envelope from the internal side and without BiPV.

As main results we obtained that, for the demand side (different energy uses), due to the destination of the buildings (non-residential) and to the profile of use (rather intermittent) there are not significant difference in terms of energy loads on yearly basis in the two scenarios (internal and external insulation).

Conversely, on the supply side, although there are not defined rules to prevent BiPV in protected buildings and rather the national guidelines for energy retrofit in historic buildings contemplate BiPV, the official opinion of the superintendence made us lose the benefit of PV generation. Fortunately, the possibility of adopting wastewater as source of heat for the heat pump was confirmed.

SDEWES2018.0439

A Methodology for the Retrofit and Maintenance of Historic Buildings Using the Leed Rating System as Guideline

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Abstract

The analysis of energy and environmental behaviour of historic buildings is a complex issue, which requires the consideration of various disciplines. It also entails an integrated method of diagnosis, simulations and use of specific instruments. For this type of application, it's necessary to understand that all the analyses are applied for the improvement and not for the adaptation to standards. Improvement means the use of a suitable device according to an appropriate architectural and environmental integration; adaptation however, means the complete alteration of the building to adapt it to legislation and necessities.

The research proposes two integrated methods: the first, to identify inefficiencies and to define the most appropriate retrofit measures for diagnosis and energy simulations of the historic buildings, also considering the environmental aspects and the sustainability of buildings; the second one, the creation of a univocal work program of LEED O+M, trying to obtain the minimum requested certification score with optimization of the technical resources and documents. Propone l'applicazione dei due metodi per il museo Ca' Rezzonico.

This method covers everything from the historic analyses to the energy audit, which includes the examination of real uses and internal necessities as well as the environmental monitoring. At the same time, it strives to balance the energy and environmental improvement required and the conservation of cultural heritage.

SDEWES2018.0561

The Computation and Valorization of the Complete Potential of Energy Resources, a Multi-Criteria Tool to Improve Sustainable Decision-Making

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Abstract

Sustainable development is not only a technological challenge, in terms of implementing economically viable and technically feasible solutions, but it needs instruments to guide policies to also improve environmentally and socially appropriate solutions. Classic indicators of financial profitability are no longer enough for decision making in energy sector.

The objective is to measure and quantify, positive and negative consequences of all energy technologies, to create sustainable solutions and to develop synergies to combat all Sustainable Development Goals (SDGs).

The Computation and Valorization of the Complete Potential of the energy resources consists in assigning a book value to all the attributes and sub-attributes of each dimension of the Integrated Resource Planning:

- Environmental dimension analyzes the consequences and alterations in the terrestrial, aquatic, aerial and biodiversity level of fauna and flora
- Technical-economic dimension, measures the project's viability, the potential and quality of energy produced, the cost of generation, the capacity factor and the technological domain
- Social dimension evaluates impacts on society, like number and quality of generated jobs, human dislocation because of a project, the comfort, the influence on human development, and the environmental imbalance in the social environment
- Political dimension analyzes involved and interested parties, the degree of acceptance, motivation and shared interests of all the society's components and the energy possession and integration

The weights of each sub-attributes in the objective function is created by a combination of social participation and experts' opinion. It is a unified tool for analyzing solutions and making sustainable decisions, applicable at all scales and sectors and promoting collective responsibility.

As said, none of the Sustainable Development Goals (SDGs) can be viable without affordable and reliable energy for all humans in the same quantity and quality level. And a tool is needed to analyze all involved attributes and to create sustainable solutions in all the world dimensions.

SDEWES2018.0232

Risk Indexes Evaluation in View of a New Showcase Designing of "L'Annunciata" by Antonello Da Messina

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Abstract

Museums are often hosted by heritage buildings, where the indoor thermal conditions are usually subjected to a free-floating regime, due to the difficulty of equipping them with HVAC systems that, generally, are highly impacting tools from a visual point of view. These technological tools, in fact, could conflict with the established arrangement of the works of art. This would represent a problem, since the indoor physical conditions of these premises must fall within the ranges of values suitable to ensure the safety of the works of art there exhibited. In addition, the increasing time spent by visitors inside museums (now offering various possibilities of leisure, ranging from the book shops to the restaurants) calls for a new attention of their indoor microclimatic conditions to comply also with the thermal comfort requirements of visitors. In the paper, a stepwise procedure is proposed, that can be easily replicated to other situations characterized by the same order of problems. Starting from the thermo-hygrometric monitoring of the site and with reference to the thermal-hygrometer requirements for the exhibited works of art (as suggested by the in force standards and rules), pertinent indicators of risk are computed. These parameters allow checking the current indoor situation and the possible needs for modifications. A discussion of these outcomes will lead to the proposal of a technical solution, suitable for the exhibition requirements of the considered site. The method is here applied to the "Palazzo Abatellis" museum building, where important artefacts are exhibited, like the famous painting of Antonello da Messina, "L'Annunciata". It is currently displayed in a showcase specifically designed by the architect Carlo Scarpa, who established the original arrangement of the Gallery. The field application of the method revealed that the indoor conditions of the room mainly fall outside the safety ranges for this oil on wood painting. Since the layout of the museum is almost unchangeable for artistic reasons, the proposed technological solution is a new showcase, inserted into the old one, able to ensure the needed thermo-hygrometric range of values for the analysed oil on wood.

SDEWES2018.0252

Addressing Thermal Comfort in Heritage Mediterranean Housing Buildings: a Spanish Case-Study

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Abstract

A high proportion of existent housing gathered in the southern parts of Europe date from the middle of the XX century. Many of them have become examples of modern architecture, becoming affected by protective laws to preserve their appearance. Housing architecture of the Modern Movement supposed a break with previous trends and raised awareness on energy matters.

Current energy policies often allow protected buildings not to fully accomplish strict requirements in order to guarantee their heritage values. Nevertheless, the lack of thermal insulation, integrated active systems and the poor quality of construction materials, result in a deficient energy performance and unsatisfactory indoor environmental conditions. Besides, the thermal inertia of these buildings is not enough to keep indoor comfort conditions and they are so much sensitive to outdoor weather changes.

The aim of the paper is to define passive strategies to improve energy efficiency in heritage residential buildings to improve comfort conditions while their patrimonial values are respected. The present work applies this idea to a heritage social housing building (1955) in Seville, a city from the South of Spain, under Mediterranean weather conditions.

In order to reach the paper aims a comfort-based analysis of two monitored dwellings is developed. Adaptive equations set by international standards (ASHRAE, ACA, ATG and CEN) are hereby used on the calculation of discomfort degree-hours, in order to see how far indoor conditions fall out the comfort band. A comparison of results with Spanish code requirements is also considered.

In order to ascertain the real performance of the case-study building, two flats went under monitoring during 9 months. Indoor variables and outdoor weather was logged. Air-tightness and thermography tests were carried out too.

After the calibration of energy models, a sensitivity analysis was performed by series of energy simulations to test the main aspects that have an impact on the global energy balance and thermal comfort of the monitored flats. The level of protection of the building appearance, together with the fact that the building is inhabited, were two evidences to take into consideration in order to build up intervention proposals.

Different hypothesis were considered: thermal isolation of walls air chambers, changing windows frames, optimizing windows glazing (solar control and low emissive) depending on the windows orientation, and setting up periodic mechanical ventilation rates for indoor air renovation.

In general, simulation results disclose a better energy performance after testing retrofit strategies. Nevertheless, the decrease on energy demand is more noticeably than the improvement of comfort conditions.

SDEWES2018.0305

Non-Reachability of the Nzeb Class for Constrained Buildings: Case Study of a Public Building Office in the Central Italy Climate Zone

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Abstract

Near-zero energy buildings (nZEB) are buildings that consume less energy than others and have high performance standard operations. Very high energy performance nZEB minimize consumption relevant to various factors: heating, cooling, ventilation, lighting, the production of domestic hot water and transportation of people and things. They use energy from renewable sources, have passive heating and cooling elements, and shading systems.

In order to achieve annual efficiency targets, set for all P.A. until 2020, as established by the Italian law in force, it is therefore important to carry out effective interventions on buildings that include particularly energy-intensive constrained buildings.

In this work, the energy needs of a historic building were assessed taking into account the variability of climatic conditions and internal loads, the thermal capacity of the enclosure, and by conducting an energy analysis through a dynamic simulation software (TRNSYS).

The study provided an analysis of the current state of energy efficiency achieved through energy diagnosis, identifying the most appropriate problems and interventions to be implemented for the transformation of the building into nZEB, and evaluating the technical and economic feasibility. Solutions have been proposed for energy efficiency aimed at achieving nZEB classification. The solutions examined the building envelope, the technical systems and the efficient generation of thermal and electrical energy.

Advanced technological solutions have been proposed consistent with the principles of technical-economic feasibility, compatibility with architectural and landscape constraints and large-scale replicability. The proposed solutions have been directed towards energy efficiency, intelligent energy management and the exploitation of renewable sources. Through the efficiency measures proposed, the consumption of thermal and electric energy performance from renewable sources have been respected. However, the presence of architectural constraints does not allow for the applicability of some essential interventions on the building envelope for energy efficiency.

It was therefore possible to demonstrate the inability to reach nZEB classification for a constrained building, despite its full compliance with the energy performance parameters required by the Italian legislation in force.

SDEWES2018.0308

Comparison of Different Data Sources in Performing a LCA of the Outer Envelope of a Passive House

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Abstract

The impacts related to the materials weight heavily and increasingly on the environmental performance of the low energy buildings. Since the Regulation mostly focuses on the reduction of the operational energy demand – like in EU nZEB standard- this cuts down the related impacts, but can increase those brought-in by materials. It means that the material/component impacts become relevant both by share on the overall impacts and by quantity, due to the large amount of products and devices that building requires to meet more and more severe energy standards. The scientific literature provides several evidences of this trend, confirming the key role that the embedded impacts play on the building environmental balance. (Thormark, C., 2002; Sartori, I., 2007; Optis, M. et al., 2010; Din, A. et al., 2016; Chastas, P. et al., 2017). Consequently, limiting the analysis of the operational phase impacts only provides a partial estimation of the building process environmental effects, while a life-cycle-based performance assessment is needed, in order to establish a more reliable and effective impact balance. The sustainable building rating systems (RS) are a possible and practical way to calculate Life Cycle Assessment (LCA) of a building process. However, the reliability of the outcome is strictly influenced by the data sources from which the information are obtained regarding the material environmental impacts. Two different methods are currently available to implement the LCA of building materials within the RS: by importing them from a generic dataset – better if suitably recognized by rating system itself- or from the Environmental Product Declaration (EPD) of the building materials. Aiming at harmonizing the assessment procedures, two recently published EN standards push for the adoption of EPD as a suitable source for this purpose (EN 15804; EN 15978). An EPD is a standardized (ISO 14025) communication scheme where the environmental impacts of a product, is assessed based on LCA technique (ISO 14040-14044). In building sector EPD is recognized by more Green Building Rating Systems (GBRSs) worldwide, such as: DGNB, ACTIVE HOUSE, etc.This study provides the comparison of the environmental impact of the outer envelope of an talian passive house, when it is calculated by using two different data sources: Ökobau dataset and the specific EPDs of the applied products. The GBRS adopted for the comparison is Active House. The comparison has shown a relevant difference between the two scenarios in all the environmental indicators: e.g. variations of about 10% for PENR and GWP, 20% for AP and EP, and 40-50% for PER and ODP. Furthermore, the effects on the GWP index belonging to different insulating layers were calculated using the latest version of the Ökobau dataset.Furthermore, the effects on the GWP index belonging to different insulating layers were calculated using the latest version of the Ökobau dataset.

SDEWES2018.0336

Possibilities to Reduce Carbon Footprints in Building Construction Sector in Serbia by Reducing the Embodied Carbon in the Design Stage

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Abstract

Civil engineering is a sector which greatly contributes to the consumption of resources (primary materials, energy, water) and waste generation. Through the implementation of the energy efficiency measures Serbia is trying to reduce the operational energy in buildings by introducing building energy rating. The construction stage of a building, regarding the embodied carbon, is still not recognized as an approach to reduction of civil engineering impact on greenhouse gases (GHG) emission.The aim of the research is to estimate the amount of carbon footprint of the analyzed building construction and study the possibility of its reduction, that is, the savings in CO_2 emissions. The analysis has been performed on a four-person family housing project designed in energy rating C. This research identifies the materials and activities with the greatest impact on the environment, so called hot spots, which are latter replaced with recycled and reused materials, thus achieving the lower amount of embodied carbon. The research results show that it is possible to reduce embodied carbon footprint of the construction within the range from 12,45% to 29,89%, in comparison with the reference building constructed with primary materials. In a scenario in which a local labour is used, it is possible to achieve further savings in carbon emissions and reach a fall of 32,31% in CO_2. The results clearly indicate that it is neccessary to analyse not only the operational phase but also the embodied carbon footprint of the building construction.

SDEWES2018.0457

Thermo-Hygrometry and Iaq Related Measurements of the Indoor Physical Conditions of Exhibition Halls for Complying International Rules and Standards

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Abstract

Off-line methods for detecting the indoor physical parameters of museums are important tools in order of continuously monitoring the conditions at which works of art are exposed. These conditions, in fact, are mandatory established by several rules and technical standards aimed at preserving these important issues of the human cultural heritage.

On the other hand, museums buildings are becoming more and more attractive for people that, apart visiting the exhibitions, tend to spend longer times inside such premises, where other cultural and leisure activities (that are responsible of VOCs emissions) are realized. This, in turn, calls for further considering the indoor microclimate parameters of museums buildings, in the aim of maintaining them at the comfort conditions for visiting people.

Both the above-cited requirements suggest to perform the indoor monitoring with equipment low impacting with the exhibition rooms arrangements, particularly by the visual point of view. Measurement equipment, in fact, is often characterized by rather high noise levels and not so small dimensions, making it a not easy task finding the correct collocation of such equipment in exhibition halls. Clearly, this requirement regards also the HVAC systems that are installed inside such spaces.

In this paper, some examples of off-line monitoring of important Sicilian museums are reported, finalized at detecting thermo-hygrometry and pollutant related parameters. Specifically, three different methods of detection are applied for the pollutant emissions measurement.

All the reported field analyses seem to demonstrate the feasibility of such methods of indoor air museums detection, placing them as useful tools for the continuous and low impacting monitoring and controlling of these relevant buildings, in this way better complying with the rules and standards concerning the suitable preservation of works of art.

Special session: Energy efficiency in industrial processes and systems

Energy efficiency in industry is gaining importance in the EU funding frameworks as a pathway for reducing the environmental impact of our society. Limiting the energy footprint of industrial processes and systems is beneficial not only to the need to reduce the greenhouse gas emissions but also to face the instability in the energy prices and to improve the reliability of supply. Economic assessment is a key issue for the innovation technologies to be applied in demonstration cases or in real industrial cases.

The session aims at bringing together research advances and technological progresses on reducing the energy requirements and pollutant emissions of industrial process and systems. The focus of the session is on advanced concepts and designs to reduce energy consumption, to exploit new ways for heat recovery and cogeneration opportunities and to improve the environmental footprint. Additionally the operation and maintenance costs for the proposed solution are also important topics to be addresses as well as the impact on the final product's quality and production rate.

Abstract may also increase the knowledge of innovation technologies by proposing mathematical approaches, numerical modeling and experimental techniques to foster the application of the proposed solutions for the enhancement of the energy efficiency of industrial processes and systems.

Session organizers:

Prof. Luca Montorsi, University of Modena and Reggio Emilia, Reggio Emilia, Italy

Prof. Andrea De Pascale, University of Bologna, Bologna, Italy

Luca Montorsi - Luca Montorsi is associate professor at the Department of Sciences and Methods for Engineering of the University of Modena and Reggio Emilia, Italy. He currently teaches Energy Conversion Systems for the Master Degree in Management Engineering and the Bachelor Degree of Mechatronics. He has supervised more than 50 MSc and 3 Phd students. He has participated in many national and international projects in the field of the energy efficiency of systems and components and he is currently participating to 2 HORIZON2020 projects for the reduction of the energy consumption and emissions in different industrial sectors. His main research activities have been focused on multi-dimensional modeling of systems and components for the development of new concepts and the design improvement in many areas, such as the cogeneration systems, alternative fuels' combustion and processes, performance prediction of conventional and renewables energy conversion systems, fuel consumption and emissions reduction in industrial processes.

Invited submissions

SDEWES2018.0157

Parametric Analysis on a Small Scale Energy System for Liquefied Natural Gas Production

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Abstract

To decrease its environmental impact, naval sector needs to develop new approaches regarding both the design and the operation of on-board energy systems, mainly to reduce pollutant in port areas. An effective solution comes from liquefied natural gas (LNG) and hybrid diesel-LNG engines. In this paper, a small scale plug&play system to produce liquefied natural gas for on-site purposes is presented. Different supply pressure from the natural gas network are taken under consideration. A parametric analysis on key cycle parameters is conducted to optimize and reduce energy consumption of the overall process taking into account various layouts. Two liquefaction processes are defined, considering respectively a Joule-Thompson valve and a turbo-expander for the gas liquefaction. In the final section, a specific case study on the Port of Ravenna is presented with also an economic analysis regarding the feasibility of the plant.

SDEWES2018.0165

Performance of a Power-to-Gas Energy Storage System Based on Integrated High Temperature Co-Electrolysis and Methanation

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Abstract

In this study, performance of a renewable energy storage system based on a Power-to-Gas conversion process, composed by high temperature co-electrolyzer of SOEC (Solid Oxide Electrolyte Cell) technology and a methanation section, are investigated, including all the thermal and electric energy needs. A parametric analysis of the feed stream composition and of the methanation section operating temperature is carried-out. Based on the first results, in order to reduce thermal energy consumption, a configuration with heat recovery is also considered. In order to evaluate performance results, efficiency indices (electric-to-fuel conversion index, first and second law efficiencies) are introduced. Results show that best set-up from the point of view of synthetic natural gas quality does not coincide with configuration with highest efficiency indices. Moreover, the configuration which includes heat recovery allows to achievesignificant increase of the first and second law efficiency indices, up to values around 70-75%.

SDEWES2018.0250

Combined Experimental and Numerical Approach for the Energy Efficiency Evaluation of the Hot Welding Process in a Packaging Machine

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Abstract

The paper presents a combined approach between numerical modelling and experimental measurements for the analysis of systems and components in the packaging process for the beverage industry. The analysis focuses on the hot welding process employed to seal the packaging material and the thermal behaviour as well as the energy efficiency of the process are investigated.

Direct measurements of the process are very difficult to carry out due to the usual assembly of the system and the low time scale of the physical phenomena involved, which prevents any experimental investigation. Therefore, an ad hoc test rig is specifically developed in order to reproduce the same operating conditions of the system and the same interaction between the packaging material and the hot welding heater as in the real machine. The test rig is equipped with a control system able to vary and monitor the main operating parameters of the process, such as the air pressure and temperature and the packaging material velocity. High frequency thermo-cameras are employed to detect the temperature on the product and to assess the influence of the heater operating conditions on the product quality.

Furthermore, the experimental measurements are employed to validate predictions obtained by the numerical simulation of the system. The computational fluid dynamics model of the heater and the moving packaging material is created and used to extend the measurements and deepen the understanding of the thermo-fluid dynamics behaviour of the system. In particular, the interaction between the packaging material and the hot air flow is investigated in order to address the energy consumption of the system and its efficiency. The good agreement between the experimental values and calculations confirms the numerical model as an efficient tool for investigating the energy efficiency in the packaging machine process.

Finally, the combined experimental and numerical approach is adopted for deriving correlations among the operating parameters that characterize the hot welding process and that can be used in the design process of the system for improving the energy efficiency and the product quality.

SDEWES2018.0263

Numerical Analysis of the Energy Efficiency Improvement in a Ceramic Kiln by Means of a Heat Pipe Based Heat Exchanger

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Abstract

This paper investigates the application of a heat-pipe based heat exchanger for improving the energy efficiency of an industrial ceramic kiln. Possible heat sources for energy recovery in a ceramic kiln are analysed and the use of the recovered heat in the heat sinks available in the ceramic process is evaluated in terms of temperature requirements and total amount of reused energy. A theoretical model is constructed based on the established, proven performance characteristics of heat-pipe technologies; furthermore, the thermal characteristics of the heat pipe heat exchanger are evaluated using a Computational Fluid Dynamics (CFD) approach of the full component geometry. The thermal and fluid dynamics properties of the heat exchanger are employed to address its influence on the operation of the real kiln using a lumped and distributed parameter numerical approach. Finally, the amount of recovered energy and the temperature of the heat available for the possible sinks are predicted as well as the reduction of the energy consumption in the ceramic process are addressed.

The numerical analysis demonstrates that the application of the heat pipe based heat exchanger in the ceramic sector leads to remarkable energy savings, which can reach close to 1 MW by recovering the heat from the different exhausts stacks of the kiln. Furthermore, the recovered heat can be exploited by other processes of the ceramic manufacturing process thus enabling savings corresponding to the amount saved from the primary source. The observations and results described within the paper support the application of the heat pipe based heat recovery to the ceramic process from the viewpoint of the improvement the energy efficiency and environmental impact and of the economic investment.

SDEWES2018.0360

Dream Project Innovative Refractory Materials to Reduce Heat Losses from a Ceramic Kiln

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Abstract

Most ceramic tiles are fired in continuous kilns, in which tiles are conveyed through the kiln on rollers. Heat is produced by natural gas combustion in burners. Energy balances drawn up on ceramic tile kilns have shown that kiln efficiency is low, because only 5 to 20% of the energy input is used in firing the tiles. The rest is lost through the flue gas stack and cooling stacks, with the fired tiles, and through the kiln walls and vault. The energy content lost from the kiln stacks could be partly recoverable implementing energy recovery systems, but the reduction of the energy lost through the kilns surfaces it is more limited. The heat losses through the surfaces of the kiln can be studied using a thermographic camera. This methodology allows analysing in detail the heat losses, which is of utmost importance in processes where this output is significant.

The DREAM project aims at improving energy efficiency in ceramic kilns through different specific actions. One of these actions is focused on the minimization of the energy losses through the walls of the kilns by developing and applying a new refractory coating on the surface of the inner walls of the kiln.

This contribution reports on industrial tests in which the new developed reflective coating was installed in a ceramic roller kiln at KERABEN GRUPO. Aim was to prove the long-term stability of the coating under real thermal and corrosive conditions and to define a procedure for testing the coating efficiency, in means of saving energy, by thermographic imaging.

Preliminary results are positive. During a first industrial test period of 130 days, the reflective coating adhered safely on the refractory surface of the inner side of the walls of the kiln with no indications of delamination or critical corrosion.

Preliminary analysis of the temperature on the walls of the kiln, carried out by thermographic technology shows that, the new coating reduces the temperature of the walls at first stages of the firing cycle, when the inner temperature is bellow 900 ºC, but it seems that at higher temperature (up to 1200 ºC), it does not affect the temperature of the external surface of the kiln.

SDEWES2018.0362

E-Use Project: Innovative Ates Systems for Energy Efficiency Buildings

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Abstract

Nowadays, the implementation of the renewable energies in buildings is growing, but many of them do not guarantee a continuous supply and need to be combined with others to supply the energy demand of buildings. The Shallow Geothermal Energy (SGE) is a suitable energy source to meet the energy demand for buildings´ heating & cooling purposes and to guarantee its supply 365 a day a year.

The 80 % of the energy used in buildings is for heating & cooling purposes. Despite of the benefits and potential of SGE, this renewable energy the most unknown and least widely used among renewables. One way of the exploitation geothermal resources is by ATES systems (Aquifer Thermal Energy Storage), which give the best performance, but also the greatest environmental and legal constraints.

The Spanish pilot has been implemented an innovative probe (DCL®-Dynamic Closed Loop) that avoids the water extraction from ground, this mean the water is kept underground, this new probe is a combination of ATES and BTES system.

The Spanish pilot is focused on the evaluation of the environmental impacts and performance of the ATES system in a context of hydric stress; hence AICE-ITC has implemented an ATES pilot plant in Nules (Castellón) to supply the thermal demand of the municipal swimming pool.

The presentation will show the most relevant results in terms of operating performance, economic savings for the City of Nules and the data of pool water temperature during the two years of study (2016-2018).

The SGE can be implemented in applications with low temperatures demands like green houses, water treatment plants (sludge drying) and sanitary hot water production.

Special session: Smart Islands - living labs for 100% renewable and sustainable communities

As defined by Smart Islands declaration signed on 28th March 2017 in Brussels: A Smart Island is an insular territory that embarks on a climate resilient pathway, combining climate change mitigation and adaptation efforts, in order to create sustainable local economic development and a high quality of life for the local population by implementing smart and integrated solutions to the management of infrastructures, natural resources and the environment as a whole, supported by the use of ICT, all while promoting the use of innovative and socially inclusive governance and financing schemes.

The goal of special session is to attract papers and presentations that will show the most recent methods, tools and analysis of various planned and implemented projects on development of smart islands. That includes smart energy systems, transport, circular economy, multi-level governance, smart tourism, ICT and others. The presented solutions could also be transferred to different locations such as cities and towns, rural and mountainous areas and even to the urban centres such as smart cites and districts.

Session organizers:

Prof. Goran Krajačić, University of Zagreb, Zagreb, Croatia

Mr. Savvas Vlachos, Cyprus Energy Agency, Nicosia, Cyprus

Goran Krajačić - Goran Krajacic, Ph.D., (http://powerlab.fsb.hr/gkrajacic/) received Ph.D Degree in Mechanical Engineering from the University of Zagreb in 2012. Since 2004 he has been working as researcher at Department of Energy, Power Engineering and Environment at the Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb. In 2007 he spent 6 months as a guest researcher in the Research Group on Energy and Sustainable Development, Instituto Superior Técnico, Lisbon, Portugal where he investigated application of small decentralized power generation and energy storages. From 2004 to 2007 he worked on the FP-6 project ADEG - “Advanced Decentralised Energy Generation Systems in Western Balkans”. The most of his work on the ADEG project was connected to development of H2RES computer program for energy planning. From 2007 to 2010 he was involved in the Intelligent Energy Europe (IEE) project STORIES – “Addressing barriers to storage technologies for increasing the penetration of intermittent energy sources”. He also helped preparation and implementation of the FP-6 project WEB-MOB, five IEE projects (GERONIMO, STORIES, SMART, BIOSIRE, FLICK THE SWITCH), two FP-7 projects JoRIEW and DISKNET and 4DH project coordinated by AAU. In 2011 he helped the team of Prof. Joško Deur in the successful preparation of HRZZ project ICT-aided integration of Electric Vehicles into the Energy Systems with a high share of Renewable Energy Sources. Since 2007 he has been working on the national scientific project: Smart Energy Storage for Sustainable Development of Energy Systems, financed by Ministry of Science, Education and Sport of Republic of Croatia. Results of his work have been published in 14 papers in CC/SCI database and have been cited more than 100 times. He reviews papers for Energy Policy and Applied Energy. He participates in teaching the courses Introduction to Energy Management and Energy Planning.

Savvas Vlachos - Mr. Savvas Vlachos was born in 1983 in Nicosia, Cyprus. He graduated in 2010 from the University of Cyprus, Department of Civil and Environmental Engineering as a Master of Engineering. He was working as an Energy Expert for the Cyprus Energy Agency from January 2009 until the September 2017 when he has been promoted to the position of director of the organization. His scope of work covers areas within the framework of renewable energy, energy savings, and sustainable transport and urban mobility. He has been involved in development of studies, audits, certifications of energy efficiency in buildings and Sustainable Energy Action Plans for local authorities. His work encompasses providing consulting services on renewable energy source technologies and energy efficiency techniques. He is a certified trainer by the Human Resource Development Authority of Cyprus with an extensive training experience in the field of photovoltaic systems, energy efficiency buildings, feasibility studies, environmental policies and buildings energy performance certification. Since January 2017, he is a Local Manager of the Programme Pioneers into Practice in Cyprus which is funded by the Climate - KIC and the European Institute of Innovation and Technology. He has been involved in many European co-funded projects as a project manager. The most significant ongoing projects: COMEPTENCE4SECAP (HORIZON2020) engaging 32 local authorities to upgrade their Sustainable Energy Action Plans into Sustainable Energy and Climate Action Plans, VIOLET (INTERREG EUROPE) improvement of regional public body to enhance energy efficiency in traditional buildings, LOCAL4GREENS (INTERREG MED) supporting local authorities in defining and implementing innovative local fiscal policies, intendent to promote renewable energy sources, ENERJ ((INTERREG MED) solving the challenges of implementation and monitoring of energy efficiency measures, project plans and policies at local level in Mediterranean , PRIMSI (INTERREG MED) tackling the key challenges of energy transition on Mediterranean islands, ENERFUND (HORIZON2020) tool for rating and scoring deep renovation opportunities, GreenS (HORIZON2020) strengthening capacity of public authorities to successfully apply GPP. The most significant previous projects: MED -ALGAE (EU, ENPI CBCMED, Mediterranean Sea Basin Programme), ELHIMED (ERDF, MED), SERPENTE (INTERREG IVC), SEAP-PLUS (IEE), SMILEGOV (EC, IEE), MEDEEA (ERDF, MED), ENERSCAPES (ERDF, MED).

Invited submissions

SDEWES2018.0237

On the Transferability of Smart Energy Systems on Islands Using Cluster Analysis – a Case Study for the Philippine Archipelago

H. Meschede*[1], E.A. Esparcia[2], P. Holzapfel[3], P. Bertheau[4], R.C. Ang[5], A.C. Blanco[5], J. Ocon[5]

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Abstract

Islands are highly diverse in their climatic, physical, social, and economic characteristics. Thus, each islands energy system needs to be designed according to its specific features. However, similarities among islands exist, which can enable fast transfer of concepts and experiences on energy systems. In the Philippines, only few off-grid islands are incorporating smart energy systems through hybrid electricity systems. While most off-grid islands still do not have access to electricity, majority off-grid Philippine islands having access to electricity are powered primarily by diesel-fired generators, which come along with limited operating time, high CO_2 emissions, low efficiency and system unreliability. Therefore, a systematic classification through cluster methods could potentially fast-track design of smart energy systems for off-grid Philippine islands.

In this work, a cluster analysis is performed for 502 off-grid islands in the Philippine archipelago, classifying the islands according to their similarities in socio-economic and physical characteristics, and local energy resource potential. The results show that most of the islands belong to five clusters of very small and small islands for which PV-battery systems would be the favourable backbone of a future energy system based on RES. These islands show a varying level of feasibility for harnessing wind energy. In medium and big islands, opportunities of linking electricity systems to water supply and thermal energy loads as well as to the transport sector, are identified and their relevance in the clusters is discussed. The results are consistent in validating the individual characteristics of chosen off-grid islands. This study supports policy makers and private investors to decide which smart energy system projects are suitable for which particular islands.

SDEWES2018.0258

Development of a Dynamic Energy Model of a Dish-Stirling Solar Concentrator

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Abstract

In the recent years, the research of alternative and renewable energy sources has significantly increased due to environmental and economic factors. The need of sustainable energy supply brought the European Community to invest in experimental campaigns on decentralised generating technologies from renewable sources. The Dish Stirling System will be crucial in that, because it shows considerable potential in high efficiency power production. The only drawback is the high cost and, in this context, the purpose of this study is to evaluate the Dish Stirling technology performance and to develop a reliable mathematical model calibrated monitoring the plant operating at the University of Palermo. The detailed dynamic simulation model, developed in TRNSYS, will allow the assessment of producibility of this technology on national territory. The model, based on the "black box" logic, was built from the efficiency curve of the Ripasso Dish-Stirling unit operating in Upington (South Africa); it made possible to obtain the electric and thermal output with the variation of the Direct Normal Irradiance (DNI) and the environmental temperature. These data came from "Meteonorm" database and shall be used in hourly base for annual simulations. Mirror soiling can contribute to a significant reduction in the performance of this system and so its contribute has to be taken into account. A preliminary analysis was made monitoring the system performance during the Concentrating Solar Power (CSP) plant operation in Palermo. This analysis helps us to obtain the efficiency curve of the Dish-Stirling System and to calibrate the simulation model. However, the economic analysis stated that the Dish Stirling technology, although it has become mature and reliable, still shows very high costs. The results obtained confirm the potential of this system, although it presents a technology disadvantage compared to PV technology, because of its strongly dependence by DNI. It is essential to install Dish Stirling Systems or similar in the future, to enable and promote the CSP sector for electricity production beyond the residential context.

SDEWES2018.0298

Greening and Sustainable Energy Approach Applied for Balearic Islands and Fiji Islands: a Comparative Study

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Abstract

The paper analyses the energetic mix used to produce electrical energy in two different contexts: the Balearic Islands and the Fiji Islands. Promoting the energetic sustainability, this work examines the availability of renewable energy sources (RES), focusing the attention on sea wave, wind and solar. The paper analyses in detail the sea wave, since this renewable energy source is currently underdeveloped in spite of the various technologies proposed over time. As a solution, the Department of Energy of the University of Palermo is designing an innovative system able to exploit the sea wave energy potential, independently of wave direction. Thanks to the cooperation of the University of South Pacific, the paper shows a comparison of the wave climate in the two contexts, to demonstrate the compatibility and the possible effectiveness of the device.

The first case of study analyses the Balearic Islands, a Spanish archipelago located in the western part of the Mediterranean Sea. Despite the progressive introduction of RES in Spain, the Balearic Islands show a strong energy dependence on fossil fuel. In the last year, the electricity generation was 6 TWh, of which 72.9% was produced from fossil fuels. Since 2012, the Balearic Islands have been electrical connected to the mainland, simplifying the introduction of renewable sources, since the local grid has increased his strength and stiffness.

The second case of study analyses the Fiji Islands, located in Oceania. In this context, the electrical sector shows a dominance of medium hydropower, due to the abundance of water and investments of the Government over the last few years. The total generation in 1997 was approximately 450 MWh, 89.4% of which from the two hydropower stations of Wailoa. The contribution of RES however is progressively reducing because of the increase of load not matched by a corresponding increment of investments in RES. Actually; in 2002 hydropower supply covered only 75% of the energy demand, because of an increase of approximately 649.5 GWh.

In conclusion, the needs of the two case studies show two different scenarios. The former shows a highly dependence on fossil fuels that in the long run can result in too high costs, but with a stiff connection to the mainland grid. The latter presents a situation where RES, especially hydropower, play an important role, but where the weakness of the main grid and the need of isolated microgrids powered with RES pose interesting engineering challenges. Sea wave energy can be strategically used with this respect.

SDEWES2018.0327

Advanced Modelling of Big Island Energy Systems

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Abstract

An increased interest for the sustainable low-carbon energy system on the islands has recently been manifested through two European Union's initiatives; Smart Islands Initiative and Clean energy for European islands. Islands represent territories of particular interest for modelling of renewable based energy systems due to their insularity. Such territorial characteristics force islands to utilize energy from locally available renewable sources in a highly efficient manner with an optimisation of supply and demand. Island territories vary significantly in their size and population density; accordingly, they require energy modelling approaches to be adapted to these conditions. In this paper, the special focus is placed on the energy systems of the big islands. Such systems represent great challenges due to their complexity and high energy demand while at the same time these features provide many potentials manifested through the exploitation of synergies between various sectors and energy types. Moreover, islands that have already shown significant progress in sustainable development require special attention in the selection of unexploited potentials and synergies. Therefore, the aim of this paper was to analyse the utilization of often neglected non-conventional biomass potential in the island smart energy system. A case study was carried out for Sicily, Italy. Furthermore, as the modelling approach is foreseen for the islands with significant progress in sustainable development, the scenarios were developed for a short-term vision.

SDEWES2018.0492

Wind Energy Potential Analysis with Sentinel-1 for Wind Turbine Installation: a Case Study Mediterranean Islands

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Abstract

Nowadays, multi remote sensing satellite methods for observing large area ocean and sea surface plays a main important role for parameters in the studies of many marine applications, oil spills, wave, fisheries, sedimets, coastal surveillance, ship detection, also nearshore and offshore wind turbine installation and exploration. This days, given the growing energy needs of humankind, main reasons for wind turbines are being installed at an ever increasing rate.

The present study, focuses on wind farm based on Sentinel 1 satellite data and also a new methodology is developed for coastal zone in the west coast of Sicily island from multi sensor satellite (SAR) is proposed. we use SAR imges for characterization of nearshore and offshore wind in the west coast of Sicily. About 35 SAR images (downloaded by ESA website) over the Mediterranean Sea (west coast of Sicily) have been analyzed and wind speeds from SAR images were extracted by CMOD-5 models. Sentinel 1 satellite data from ESA, we are used and analysis images are investigated in this study. Images data picked from 2017 year. The SAR images used for wind direction, wind speed, has been analyses by SNAP software and then GIS for mapping and ENVI 4.8 software for region of interesting (ROI tool) in this study for Sicily island. According to wind data in this area we use Matlab-Simulink model for output wind turbain installation in west coast of sicily. In during this study zoom on wind speed and detection analyzing based on SAR satellite images and best possition for wind turbines instalition. This method to the SAR satellite images use for wind maps, benefit about wind turbines instalition Sicily islands.

The structure of the paper includes in Section one a description of the study site (sicily islands), Sentinel 1 satellite data used. In Section two the results from the case study based on satellite. Section three presents the Sentinel 1 based wind farm based on simple averaging of the wind fields. And at the end Simulation of two proposed models for the construction of wind farm in this area.

In this paper, reported analysis carried out by using Sentinel 1 satellite 1 imagery (SAR) to detect wind power in the west coast of Sicily close to the Favignana island's. SNAP software has been used on Sentinel 1 imagery in order to detect wind field estimation. The software can be applied to Sentinel 1 images, using this software, the wind close to the shore have been successfully detected. The preliminary results are considered successful and consistent, with a high degree of applicability to other Sentinel 1 satellite images. Satellite measurements prove to be an essential tool for wind detection and monitoring.

SDEWES2018.0587

Integrating a High Share of Variable Renewable Energy by Utilizing Smart Energy Systems Approach: the Case of a Caribbean Island

D.F. Dominković*[1], G. Stark[2], B. Hodge[2], A. Schrøder Pedersen[3]

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Abstract

Security of supply, clean air and climate mitigation are often the goals of the energy transition of islands and island-states. Nowadays, islands and island-states in the Caribbean often rely on expensive and polluting diesel generators to meet the electricity demand. One possible solution to both security of supply and carbon emissions reduction is to integrate larger shares of solar and wind energy. In order to integrate a large share of variable renewable energy sources, a smart energy systems modelling approach has been used, integrating power, cooling, transport and water desalination planning. A unit commitment and economic dispatch tool (PLEXOS) was used for modelling. Flexibility in the energy system was achieved by smart charging of electric vehicles, flexible operation of reverse osmosis desalination plants and ice storage in hotels and resorts. Time resolutions were 5-minutes and 1-hour and difference in curtailed energy by using different time resolution was calculated. The case study was carried out for a typical island-state located in the Caribbean with an approximate population of 100,000. Electrified transport had a share of 11.9% (taxis and buses), while the ice storage of hotels and resorts was equivalent to 3 days of average cooling demand (820 MWh). Reverse osmosis had 38% of excess capacity compared to average daily water desalination demand. It was shown that 78% of electricity needs could be met by variable renewable energy sources by 2020 (out of which 82.4% by wind and 17.6% by solar), at a similar economic cost to the present, fossil fuel based energy system. Curtailed energy amounted to 1.0% of the total electricity generated on a 5-minutes time resolution, compared to 0.07% on a 1-hour time resolution.

Special session: Salinity Gradient Power (SGP) and Sustainable Water Desalination

Water and Energy nexus is a topic of crucial importance nowadays and is raising an increasing interest among scientific and industrial communities. A significant growth of membrane technology for water treatment has led to a dominant role of membrane processes in the water desalination market. Moreover, this growth has also rapidly boosted the development of the so-called Salinity Gradient Power (SGP) technologies for the production of renewable and sustainable energy. This is generated from a concentration difference which can be naturally available or suitably created via artificial saline solutions. The latter are used in SGP-closed loop applications (SGP Heat engines) where low-grade heat is converted into power via SGP technologies. Finally, increasing studies have been very recently devoted to the synergic coupling of SGP and desalination technologies boosting research towards new frontiers of sustainable energy and water regeneration from unconventional resources. The present special session on this fascinating area is intended to represent a platform to share innovative methodological approaches and data or results obtained by field installations. Covered topics include:

- SGP technologies in open-loop applications;
- energy storage and conversion through SGP technologies;
- conversion of low grade heat into power via SGP technologies;
- low energy desalination processes;
- integration of desalination and SGP technologies;
- waste water treatment and valorization through SGP technologies

Session organizers:

Prof. Giorgio Micale, Università degli Studi di Palermo, Palermo, Italy

Dr. Alessandro Tamburini, Università degli Studi di Palermo, Palermo, Italy

Prof. Fernando Tadeo, University of Valladolid, Valladolid, Spain

Dr. Jan Post, Wetsus, European centre of excellence for sustainable water technology, Leeuwarden, Netherlands

Giorgio Micale - Dr Giorgio Micale is a Full Professor of Conceptual Design of Chemical Processes. He has been responsible of most of the above-mentioned EU projects. Core research topics are the study of Conventional and Renewable Energy Desalination processes, Salinity Gradient Power processes, Computational Fluid Dynamics, Mixing and Multiphase Flows, Computer Aided Process Engineering. He currently leads the UNIPA team within the RED Heat-to-Power, REvivED, ReWaCEM, BAoBAB and ZERO BRINE projects building-up significant expertise in the area of electro-membrane processes, desalination and salinity gradient power technologies and brine valorisation processes. He was awarded with the Senior Moulton Medal 2013 by the Institution of Chemical Engineers (UK).

Alessandro Tamburini - Alessandro Tamburini graduated in chemical engineer in 2006 and took his PhD in Nuclear, Chemical and Safety Technologies at the Università degli Studi di Palermo in 2011. He is currently assistant professor in Chemical Process and Plant Design at the same university. His research is focused on the experimental and numerical analysis of complex systems including multiphase stirred tanks and membrane-based units. Research interests and activities involve the following topics: stirred tank reactors, membrane-based desalination technologies as Membrane Distillation and Electrodialysis, brine exploitation, Salinity Gradient Power (SGP) technologies and applications (e.g. SGP-Heat Engines, low-energy desalination, SGP-based battery,). He has published more than 80 works on these topics as journal papers, book chapters or conference contributions. He is a reviewer of about 15 international Journals. He has participated to many EU-funded and national projects on water desalination and renewable energy technologies as well as on SGP processes. He is currently involved in five EU projects of the Horizon2020 program. He was awarded with the Senior Moulton Medal 2013 by the Board of Institution of Chemical Engineering (UK). He is a member of the European Desalination Society and of the Associazione Italiana di Ingegneria Chimica.

Fernando Tadeo - Fernando Tadeo is a currently a full Professor at the School of Engineering (Industrial) of the University of Valladolid, Spain, leading a multidisciplinary research group in Advanced Process Control. He graduated from the University of Valladolid, in Physics in 1992, and in Electronic Engineering in 1994. After completing an M.Sc. in Control Engineering in the University of Bradford, U.K., with the top mark of the class, he went back to Valladolid, where he got his Ph.D. degree in Automatic Control, with Honors. His main interest area is Process Control (In particular in Desalination) and Renewable Energies (Wind, Solar and Osmotic Energies).

Jan Post - Jan Post is an experienced Program Manager at Wetsus with a demonstrated history of working in the research industry, skilled in Research and Development (R&D) on Water Technology and Energy Technology, acknowledged with numerous patents, grants and awards. He holds an MSc in Civil Engineering from Delft University of Technology and a PhD focused in Environmental Technology from Wageningen University. Jan Post is also co-founder of start-up company AquaBattery. Wetsus, European centre of excellence for sustainable water technology is a facilitating intermediary for trendsetting know-how development. Wetsus creates a unique environment and strategic cooperation for development of profitable and sustainable state of the art water treatment technology. The inspiring and multidisciplinary collaboration between companies and research institutes from all over Europe in Wetsus results in innovations that contribute significantly to the solution of the global water problems. Wetsus' scientific research program is defined by the private and public water sector and conducted by leading universities. AquaBattery is developing an electrical storage system that is 100% sustainable. The so-called Blue Battery is an innovative product that stores electricity solely using water and table salt. This invention aims to revolutionize the energy storage world and to foster the growth of renewable energy technologies around the globe.

Invited submissions

SDEWES2018.0137

Maximum Net Power Density Conditions in Reverse Electrodialysis Stacks

M. Ciofalo*[1], M. La Cerva[1], M. Di Liberto[1], L. Gurreri[2], A. Cipollina[2], G. Micale[2]

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Abstract

Reverse Electrodialysis (RED) harvests electrical energy from a salinity gradient. The maximum obtainable net power density (NPD) depends on many physical and geometric variables. Some have a monotonic (beneficial or detrimental) influence on NPD, and can be regarded as “scenario” variables chosen by criteria other than NPD maximization. Others, namely the thicknesses H^{CONC}, H^{DIL} and the velocities U^{CONC}, U^{DIL} in the concentrate and diluate channels, have contrasting effects, so that the NPD maximum is obtained for some intermediate values of these parameters. A 1-D model of a RED stack was coupled here with an optimization algorithm to determine the conditions of maximum NPD in the space of the variables H^{CONC}, H^{DIL},U^{CONC}, U^{DIL} for different combinations of the “scenario” variables. The model accounts for entrance effects, property variation, concentration polarization, axial concentration changes, osmotic, electro-osmotic and diffusive fluxes, and can deal with complex channel geometries using Ohmic resistances, friction factors and mass transfer coefficients computed by 3-D simulations.

SDEWES2018.0227

Desalination of Brackish Groundwaters with Forward Osmosis Coupled with Nanofiltration for the Recovery of Draw Solutes

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Abstract

Groundwater is one of the most important water sources for drinking water, agriculture, and for industrial uses. However, the availability of fresh groundwater has declined over the last decades due to its exploitation and environmental pollution. Research is now shifting towards developing treatment solutions to exploit brackish groundwater.

In this study, a two-step membrane process is evaluated, coupling the innovative technology of forward osmosis (FO) with low-medium pressure nanofiltration (NF) to recover draw solutes and to produce high quality water. Two real brackish groundwater samples with different salinity and content of organics were analyzed and used as feed solution. Two inorganic salts, $MgCl_2$ and $NaSO_4$, an organic compound, glucose, and a blend fertilizer were evaluated as draw solutes.

Results suggest that $MgCl_2$ and $NaSO_4$ represent the best draw solutes thanks to the high water fluxes achieved in FO at relatively low osmotic pressures (11 and 9 LMH at 15 bar of osmotic pressure, respectively), and smaller losses due to reverse flux. Complete recovery of the two inorganic draw solutions was achieved by loose (NF270) and tight (NF90) nanofiltration membranes, used for Na_2SO_4 and $MgCl_2$ respectively. A total water recovery of 65% was achieved with reasonable water fluxes for the coupled system. No significant membrane fouling or scaling was observed. However, further investigation is ongoing to understand the possible significance of these phenomena in real application. Chemical analysis at the end of the two-step membrane process confirmed that water was of high quality and contained negligible concentration of organic compounds and total dissolved solids. Overall, the FO+NF technology was proven to be as efficient and possibly advantageous compared to the current system consisting of ultrafiltration followed by reverse osmosis. While the quality of the obtained water between the two alternatives is comparable, the FO+NF system presents lower fouling and would be intrinsically more easily coupled with renewable energy sources.

SDEWES2018.0260

Evaluation of the Potential of a Pressure Retarded Osmosis Power Plant in the Magdalena River Based on Field-Data

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Abstract

INTRODUCTION

Renewable electrical energy can be produced through the controlled mix of two solutions with different salt concentrations (salinity gradient energy, SGE). This situation of having two streams with high salinity gradient across them can be found naturally at river mouths. In this study we consider the system formed at the Magdalena river mouth in the Caribbean sea, to assess its potential for electrical production via salinity gradient technology, specifically considering pressure retarded osmosis (PRO). Experimental on-site data has been acquired and used to propose a preliminary design of a PRO plant.

METHODOLOGY AND PRELIMINARY RESULTS

The Magdalena river mouth presents a unique opportunity for SGE processes due to its morphology, which allows the availability of sea and river water at a small distance. Temperature and salinity data have been gathered in both river and sea. They have been used to simulate a PRO process employing Touati model for water flux calculations. Membrane physical properties are a critical aspect of PRO processes, mainly its salt and water permeabilities. Those permeabilities have been chosen according to experimental results provided by other authors. In order to represent the process more realistically, variation of the available salinity gradient along the membrane must be considered. Simulation of the process with a division in several stages is thus required. A countercurrent flow configuration was chosen. The river and sea flowrates are set to 20m^3/s, which keeps the Magdalena river flowrate well above its minimum environmental limit. Power densities of up to 11 W/m^2 can be reached.

A second step to assess the potential of the aforementioned proposed design is to deduct the pumping (7%) and pretreatment (57%) energetic costs from the electrical power calculated previously. It is also important to consider the power losses in the turbine (20%). The effective net power amounts to 2.3 MW out of 15MW gross.

CONCLUSIONS

It has been shown that power densities could surpass the limit of 5 W/m^2, which is commonly accepted as the minimal value for an economically feasible design. The net power potentially achievable fits in the range of those of small hydropower plants.

SDEWES2018.0282

Modelling Analysis of Thermolytic Red- Heat Engine

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Abstract

Salinity gradient heat engines represent an innovative and promising way to convert low-grade heat into electricity by employing salinity gradient technology in a closed-loop configuration. In this closed-loop, the production unit is combined with a thermally driven regeneration unit to restore the initial salinity gradient. NH_4HCO_3-water solutions has been proposed as working fluids in such system thanks to their capability to decompose at low temperatures.

In this work, a model of a reverse electrodialysis heat engine fed by NH_4HCO_3-water solutions is presented. The model consists of two validated sub-models, the one for the reverse electrodialysis unit, the other for the stripping/absorption regeneration unit. The integrated model was used in order to predict the performance of the system. The effect of operating and design parameters on the energy and exergy efficiency of the system was investigated. Finally, a perspective analysis was performed by considering the adoption of enhanced ion exchange membranes.

SDEWES2018.0286

Potential of Reverse Electrodialysis in Real Environments

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Abstract

Salinity gradient is a non-conventional renewable energy form based on the recovery of the Gibbs free energy dissipated from the mixing of solutions at different concentrations. Salinity gradients are extensively available worldwide in natural reservoirs or as a consequence of industrial/urban activities. Reverse Electrodialysis is a promising and innovative technology able to convert this energy of mixing directly into electric current.

The present work analyses a number of different real scenarios worldwide distributed where salinity gradients are available. The specific Gibbs free energy of mixing available in each specific scenario is calculated. A technical-economic model of the Reverse Electrodialysis unit is presented. The model is used to evaluate the power density and yield that can be harvested in each real scenario using a reverse electrodialysis unit. Finally, an economic analysis including the estimation of the levelized cost of electricity is presented for each investigated scenario.

SDEWES2018.0289

Exergy Analysis of Reverse Electrodialysis Heat Engine with Multi-Effect Distillation Regeneration Stage

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Abstract

The increasing worldwide energy demand is rising the interest on alternative power production technologies based on renewable and emission-free energy sources. In this regard, the closed-loop reverse electrodialysis heat engine (RED-HE) is one of the most promising technologies currently under investigation. This technology produces electric power by harvesting the salinity gradient energy released from the controlled mixing of two artificial salt solutions with different concentrations. Low-grade heat (T < 100 °C), derived from any industrial process is used in a multi-effect distillation (MED) unit to restore the initial salinity gradient of the solutions. In this work, a comprehensive exergy analysis at component level is applied to the RED-MED HE, determining the potential of the waste heat to power conversion. In particular, sensitivity analyses have been performed to assess the influence of the main operating conditions (i.e. solutions concentration and velocity) and design features (stack aspect ratio), identifying the most advantageous scenarios. Also, the effect of new generations of high performing membranes has been considered. Results show that using high-performing membranes, inlet solutions concentration and velocity of 3.87 – 0.01 M and 0.25 – 0.82 cm/s, respectively, and a stack of 0.24 - 1.03 m (width-to-length), a global exergy efficiency of 26.5% is reached.

Sustainable resilience of systems

SDEWES2018.0198

Drainage System and Flood Control as a Preliminary Structuring Axis for Urban Planning: Case Study of the Acari River Basin, in the Metropolitan Region of Rio de Janeiro

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Abstract

In the last decades, the Metropolitan Region of Rio de Janeiro, Brazil, like most other urban centers in underdeveloped countries, observed a strong vector of disordered urban growth, often associated with inadequate planning. Several areas of environmental value, especially flood plains, were occupied informally and irregularly. In addition to the fact of being exposed to flood hazards, these occupations contribute significantly to amplify the flood itself, due to increased runoff generation and higher flood peaks. Soil waterproofing and the suppression of natural spaces previously used by rivers are the main drivers of this process. Floods may cause: people to be exposed to sewage and garbage, exposing them to waterborne diseases, losses to buildings and their contents; traffic blockage; and economic losses and incapacity of recovering from these losses (in successive events); and environment and urban degradation. Thus, this article discusses the role of urban drainage and flood control as a preceding determinant in urban planning, taking water as a structuring axis for city development. Therefore, seeking to support this perception, a bibliographic review was made to find historic elements that put in evidence the significance of this proposition. In addition, a critical urban watershed in the Metropolitan area of Rio de Janeiro was modelled, and hydrodynamic simulations were performed. The first simulation represented current flooding situation. It shows the negative effects resulting from disordered urban growth and how the successive flood events may ruin a community economy. Complementary simulations, modifying the system set-up, were developed to explore and strengthen the concept that urban drainage can intermediate the natural watershed needs while providing safe city conditions. The modified drainage system setup was based on sustainable urban drainage concepts integrated with the use of the urban open spaces system, improving resilience to floods and allocating water volumes in adequate spaces for re-organizing flood flows. The flood maps obtained for the two scenarios were analyzed together with several other urban layers representing other urban systems. Thus, it was possible to observe the gains brought to the city by comparing a scenario in which the drainage system is deficient with another in which rainwater management works properly, proving the importance of the drainage system as a structuring element for urban planning.

SDEWES2018.0207

Index of Risk to Material Recovery Capacity

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Abstract

The concept of Risk has a variety of definitions and is generally composed of two parts: the possibility (or probability) of an event and the impact (or consequence) associated with the occurrence of that event. The first part depends on the source of the risk, as an example the intense rainfall and the process of its transformation into flows (and subsequently floods). The second one reflects the vulnerability of the local population exposed to flood events and is represented by considering three aspects. The first aspect is the Exposure which represents the presence of assets and people in the affected area. The second aspect is the Susceptibility that represents the population and objects exposed, which are damaged during the flood event. The third one is the Value, which quantifies the potential monetary impacts. Finally, in the opposite direction to materialization of risk, the concept of Resilience arises, which consists of the ability to absorb impacts and recover from unexpected events associated with natural disasters. In this context, the proposal is to create an index to support the planning and design of urban drainage solutions, adopting a methodology that starts from the concept of Risk. This index represents a socioeconomic parcel of the flood risk, through two indicators, the Relative Value Indicator (I_{rv}) and the Vulnerable People Indicator (I_{vp}). The I_{rv} represents the economic recovery capacity of a region against the damages of a flood event. It is calculated by the ratio between potential economic losses and saving capacity. Savings capacity, in turn, is represented by the difference between the total income and the average expenditure of a family. The I_{vp} represents a part of the region's social vulnerability, represented by the percentage of people most vulnerable to aspects of flood events related to the hazard indicator. The hazard indicator is represented by the Speed Factor, which directly indicates the potential for dragging people during a flood. The Index of Risk to Material Recovery Capacity is applied to the Canal do Mangue Watershed, central region of Rio de Janeiro, Brazil. This region suffers severe impacts from floods. The final results generate a variation of vulnerabilities for different places of the basin, from the socioeconomic point of view, subsidizing decision-making for investments in protection designs.

SDEWES2018.0445

Effect of Non-Native Invasive Plant Mikania Micrantha H.B.K. on Soil N Transformation Through Allelopathy

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Abstract

Allelopathy has been regarded as a mechanism for successful non-native plant invasion. The invasion success of exotic plants has the potential to alter N cycling and soil microbial communities through allelopathy. However, it is not clear if and what effects of allelopathic substances may exert on N cycling, and we know little about the allelopathic effect of invasive plant on the ammonia-oxidizers. The non-native plant, Mikania micrantha H.B.K. (M. micrantha), has invaded many forests in south China, and recent studies have suggested it has allelopathic potential to alter soil microbial community. Thus, we hypothesized that M. micrantha could influence soil N transformation through allelopathy. The changes of soil N properties (total N, nitrate, ammonia) and soil ammonia-oxidizing bacteria (AOB) and archaea (AOA) were measured after treating with different concentrations of aqueous extracts of M. micrantha. Our results showed that plant extracts increased both NO3 - and NH4+ in soil, whereas no significant difference existed among the three extract treatments. In addition, the extracts increased the soil nitrification rates under all the treatments. Quantitative analysis of the amoA genes revealed that the extracts of invasive species support a higher AOB abundance than that of control treatments. AOA abundance treated with invasive extracts was similar to native extracts. Our results suggest that the water soluble allelochemicals of M. micrantha improved soil nutrient availability, invasive plants promote the activity and population of ammonia-oxidizers through allelopathy, which may contribute to the further invasion.

SDEWES2018.0536

Pluralistic Evaluation System of Vulnerability to Climate Change for Local Environmental Planning

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Abstract

There are needs of vulnerability assessment for global climate change. Local vulnerability is assessed for multi-sector approach to suggest adaptation policy at local governmental level, as soon as possible. The assessment will be conducted considering a future socio-economic change (population distribution, landuse, etc). Vulpes (Vulnerability Pluralistic Evaluation System) was developed for mapping local vulnerability to climate change for local environmental planning. Although many discussion on definition of vulnerability, local vulnerability was considered as the decrease of the quality of life caused from increase of disaster risk or change of ecosystem and socio-economic system with changes in regional climate. We will demonstrate simulation results of the system based on the future change of population, landuse, and socio-economy.

At present, there is a need for vulnerability assessment for global climate change. Local vulnerability is herein assessed using a multi-sector approach to suggest adaptation policies at the local governmental level. The assessment is conducted considering future socio-economic changes (population distribution, landuse, etc.). The Vulnerability Pluralistic Evaluation System (Vulpes) was developed for mapping local vulnerability to climate change for local environmental planning. Although the definition of vulnerability is a matter of debate, local vulnerability was herein considered as the decrease in the quality of life caused by an increase in disaster risk, or changes in the ecosystem and the socio-economic system resulting from changes in regional climate.

SDEWES2018.0567

Resilience of the Slovakian Power System to a Removal of the Brown Coal-Based Generation Capacities

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Abstract

Decreasing the consumption of the domestic coal corresponds to the requirements of the general economic and environmental interest of the EU energy policy. The Commission proposed to facilitate the energy system transformation of the coal mining regions under the "Coal Regions in Transition Initiative" where Slovakia has been chosen as a pilot case to be analysed.

The objective of this study is to assess the generation adequacy of the Slovakian electricity grid as the most important consumer of the domestic brown coal is the thermal power plant Nováky with installed capacity of 266 MWe. A European wide unit commitment and economic dispatch model is used to provide techno-economic analysis of alternative technological options to the existing coal power plant.

Firstly, we compare the modelling results of 2016 with historical records to see how accurately the model replicates the power system's behaviour. Next, we present a reference scenario where the brown coal power plant continues its operation in 2030. And then we analyse three different alternative scenarios to support an early deployment of the strategy towards low carbon electricity generation: i) power plant conversion from coal to natural gas; ii) fuel switching to biomass and iii) geothermal technology option.

Our results show that the electricity price drops in all scenarios where the brown coal fuelled generator is replaced with other type. Operation of the geothermal plant has the lowest marginal generation cost. As a consequence net export under this scenario increases by 672 GWh compare to the reference scenario. The objective function of the optimal dispatch of power generators and demand in the modelled electricity system is a maximisation of social welfare. The socio-economic welfare increases in all three alternative scenarios. Increase in consumer surplus is around 2 M€ per year. Producer surplus has the highest increase under the geothermal option and equals to 28 M€ per year.

This study presents quantitative insights to the Slovakian electricity system showing an increased social welfare resulting from speeding up energy transition away from coal. The presented analysis improves the understanding of implications of such transition ahead of planning the national energy policy and regional priorities.

SDEWES2018.0616

Conveying Complexity, Setting Priorities and Reaching Targets: a Commented Review of Environmental Indicators and the Challenges Ahead

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Abstract

Global attention on sustainability and environmental issues has increased exponentially in the last decades, reaching a great political momentum with the recent Paris' COP21. Policy makers always more frequently refer to these concepts as guidelines in their work, but also financial markets and everyday consumers seem more and more sensitive to the issue. Now a general question hangs on our heads: how do we measure sustainability, in a meaningful and fruitful way? Until today, and probably for a long time, indicators are the only tool we have at hand. The scientific community has created many of them: some more practical, to cope with the political necessity of using clear and simple tools, and some more complex, until now mainly used for academic purposes. Unfortunately, none of these has proven so far to be a game-changer, in the pursuit of the most urgent tasks of sustainability. In this paper, we review some of the most relevant environmental/thermodynamic indicators in the scientific debate of recent years, marking characteristics, boundaries, strengths and critical aspects that have been raised by the community. Some general comments on the trade-offs between communicability and complexity complete the article.

Sustainable technologies

SDEWES2018.0211

A Probabilistic Inference Model of Municipal Solid Waste for Apartment Buildings in the Early Design Stage

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Abstract

In this study, a model for infer long-term Municipal Solid Waste(MSW) emission for apartment buildings is presented. The proposed model estimates the amount of MSW generated by the limited information available at the early design stage of the building. It can be used to establish a sustainable building system and a waste management plan since it can predict changes in the amount of MSW generated due to changes in the occupant configuration of the apartment building.

The emissions of Municipal Solid Waste are closely linked to human behavior. In the case of residential apartment buildings, MSW emissions are largely on the characteristics of households. space unit size and number of household members is the main drive factor of Municipal Solid Waste emissions.

Regression models have been proposed in the past that are based on the size of apartment units and the number of household members. But

However, in countries experiencing rapid population changes such as the Korean society, the average number of households in residential buildings changes drastically. Therefore, it is necessary to infer the resident information when designing the system and to calculate the demand base on the information.

The models presented in this study infer the charateristics of household residing in apartment buildings based on population census and housing consumption. Based on this, we estimate the MSW output of the long term.

The results of this study confirm that the heuristic method can be used for national statistics data and end-use consumption units, when suggesting approximate values for MSW emissions. We have verified the proposed plausibility through the trial utility.

SDEWES2018.0503

Determination of Wind Energy and Wind Turbine Characteristics at Different Sites in Kuwait

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Abstract

Wind energy continues to be one of the fastest growing forms of electricity generation in the world due to continuous improvement in wind turbine technology and economical competitiveness with conventional power plant production. An analysis of wind energy characteristics and potential for 5 locations namely: Al-Huwaimliyah, Al-Mutla, Al-Taweel, Um Omara and Al-Wafra in Kuwait are presented in this paper. The analysis is conducted using measured metrological data at 10m height for a 3 year period.

Results show that Al-Huwaimliyah has the most promising wind energy potential when compared to other locations. It is classified as having good wind resource potential. Other locations are classified as moderate wind resource potential. The measured average wind speed over three years of Al-Huwaimliyah is 5.7 m/s and wind energy density of 180.8 W/m^2. Moreover, for Al-Huwaimliyah, large-scale commercial wind turbine characteristics are determined using their operational characteristics and performance curves. It has been found that the energy generation varies from 4.95 to 8.70 GWh, the turbines efficiency varies from 0.30 to 0.38, the availability factor varies from 0.85 to 0.94 and the capacity factor varies from 0.31-0.50.

SDEWES2018.0507

Dip Coating Deposition of TiO2 Doped with Rare Earths Nanoparticles with Self-Cleaning and Photocatalytic Properties Onto Glass

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Abstract

Self-cleaning glass samples were coated with a thin layer of TiO_2, which acts as a photocatalyst and water affinity modification agent. TiO_2 absorbs radiation at wavelengths in the UV region, producing a separation of charges (e-/h+), which allows a series of redox reactions to occur on its surface. In this study, thin films of TiO_2, pure and doped with Er^{+3} or Y^{+3}, were successfully deposited onto a glass substrate by the sol–gel dip-coating method, to produce self-cleaning and superhydrophilic surfaces. The thin films were characterized by X-ray diffraction, atomic force microscopy, UV–vis spectrophotometer and the photocatalytic degradation of oleic acid. The optical properties and wettability were not affected by the Er^{+3} or Y^{+3} content but the photocatalytic efficiency in the degradation of oleic acid under UV irradiation was improved as the Er^{+3} or Y^{+3} content increased. A remarkable enhancement was observed in the hydrophilic nature of the TiO_2 thin films.

SDEWES2018.0518

Commercial Demonstration of Solid Fuel Production from Municipal Solid Waste Employing the Hydrothermal Treatment

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Abstract

Up to now, the only commercialized ways of municipal solid waste (MSW) treatment are mass land-filling and mass burning. In Japan, most of burnable wastes are incinerated, but not in other countries, and still land-filling is the most popular way of waste treatment all over the world. But the world recent trend is to prohibit or limit land-filling of wastes while citizens do not want to increase waste incineration in developed countries as well as developing countries. On the other hand, major part of the world is discharging non-segregated municipal solid wastes. Thus we have to find out the utilization ways alternative to incineration for non-segregated MSW. Pre-treatment of wastes requires crushing, drying and deodorizing, which are normally different processes. But we have developed innovative hydrothermal treatment technology (HTT) which can perform these three pre-treatment functions in one process utilizing high pressure saturated steam. Non-segregated MSW are fed into the reactor, and then, 220℃, 2.5MPa saturated steam is supplied into the reactor for about 30 minutes and the blades installed inside the reactor rotates to mix MSW and steam for about 10 minutes. Then the product is discharged after extracting steam. The product is powder-like substance and the moisture content is almost the same as the raw material, but is easily dried by natural drying. The inert material such as metal, glass and stones can be easily sieved out after drying. There is almost no bad smell in the solid products, and the products can be used as solid fuels which can be easily mixed with coal for power generation or cement production. Only 10-15% of the product is enough for steam production in a boiler. HTT has already commercialized in Japan, China and Indonesia.

SDEWES2018.0544

Conversion of Microalgal Biomass to Biochar

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Abstract

Microalgal biomass is known as a third generation feedstock that is sustainable for the production of biofuels and other valuable products. Microalgae are receiving increased attention in this few years due to its applicability in biomass production and implications in carbon capture. Microalgae can help to mitigate large amounts of CO_2 emissions as about half of the dry weight of microalgal biomass is carbon. With the high carbon fixing or photosynthetic efficiency, microalgae contribute greatly to greenhouse gases emission reduction and simultaneous produce renewable feedstock for biofuels. Conversion of microalgal biomass into biochar is one of the approaches in context of biorefinery where microalgal residue can be utilized for carbon sequestration or other applications. Microalgal biochar was produced using pyrolysis in a fixed-bed reactor with a yield of 26.9%. An alkaline pH value of microalgal biochar was showed with H/C and O/C atomic ratios beneficial for carbon sequestration and soil application. The potential use of microalgal biochar as an alternative coal was also demonstrated with the heating value of 23.42 MJ kg^{-1}. Microalgal biochar exhibited a surface morphology which suggested its applicability as a bio- adsorbent. The cultivation of microalgae and production of its respective biochar can be a potential approach as one of the clean technology for microalgal biorefinery toward a sustainable environment.

SDEWES2018.0622

Environmental Potentials of Resource Recovery by Membrane Technology in the Copper Plating Industry – a Life Cycle Assessment Approach

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Abstract

Over the last decades, there has been a growing awareness on environmental aspects of industrial processes, as well as aspects such as water and resource consumption. In order to improve resource efficiency, the ReWaCEM project aims at using membrane technology for water and resource recovery. This paper aims at providing an overview on the performance of the membrane technology and deriving information on the future potentials by using Life Cycle Assessment (LCA).

In this study, an LCA is performed to identify the potentials of membrane technology in a copper plating process in Spain. The installation of a diffusion dialysis (DD) treatment unit has the objective to recover sulfuric acid and process water and therefore aims on an in-house recycling of these streams. Currently, waste water loaded with sulfuric acid is treated and disposed, resulting in a rather high consumption of water and sulfuric acid. An expected effect of using the DD unit is a reduced demand of fresh acid and copper. An LCA model representing the operation both with and without using the DD unit was developed in the GaBi 8 software. Global Warming Potential (GWP) and Blue Water Use for both modes of operation are analyzed and compared. The expected performance of the implemented DD pilot plant is the treatment of around 45% of the waste water stream from the electroplating process. A first evaluation of the LCA model shows a reduction for both GWP and Blue Water Use within the waste acid treatment due to the reduced demand of sulfuric acid and lower electricity consumption. Results will be shown in detail in the presentation.

The performed Life Cycle Assessment shows potentials for the implementation of the DD technology in the copper plating industry. Nevertheless, the expected performance parameters need to be validated by the installation of such a treatment unit and its daily operation in the plant.

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Waste and wastewater treatment and reuse

SDEWES2018.0508

Analysis of Deposit-Based Packaging Waste Management System in Croatia

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Abstract

In industrialized countries rejected waste packaging participates in domestic municipal waste with a high share. In the European Union of an average 500 kg/cap of municipal waste, 140 kg/cap is packaging waste. The EU specific targets for packaging waste and its recycling and recovery are defined as minimum 55% rate for recycling that will be raised to 75% by 2030. Croatia is lagging behind other EU/EEA countries with a 52.7% of a recycled packaging waste. A large quantities of packaging waste are still deposited at landfills in Croatia.

The packaging waste management through the deposit system is one of the ways to ensure sufficient quantities of these materials for the production of fully recycled packaging. Deposit systems have proven themselves with large amounts of collected and recovered waste packaging with a small amount of impurities within the collected material (which is a prerequisite for high-efficiency recycling in the closed loop system). Deposit systems in Europe regularly achieve collection rates of 80-95% while systems without deposits achieve collection rates of 40% on average. Today, around 40 countries and regions in the world have implemented it.

This paper offers deeper insight into functioning and sustainability (environmental and economic) of the deposit-based packaging waste management system in Croatia. In the paper, a detailed analysis of the deposit based waste management system for waste beverage packaging was made. Also, a comparison of waste beverage packaging management systems with five best performing EU and EEA countries was done. It was found that Croatian deposit system lags behind similar systems in other European countries. For this reason, a SWOT analysis was conducted and weak spots identified. Based on that, recommendations and measures to improve the system have been defined aimed at identifying the payers in the deposit system, system controlling and monitoring (including strong digitalization), improvement of transparency and reporting channels throughout the system, and improvement of the system efficiency. Only then such system could reach its full potential and thus reduce the system costs for all stakeholders while simultaneously increasing the environmental benefits.

The work done so far is just a first stage of the research that will also include an LCA-based analysis as well as the detailed economic analysis with the final aim of determining the sustainability and a ”real” cost of the deposit-refund system (per recovered container).

SDEWES2018.0563

Removal of Coliforms During Summer and Winter Months in Anaerobic, Facultative and Maturation Ponds Used for Wastewater Treatment

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Abstract

Waste stabilization ponds (WSPs) are preferred for the treatment of domestic/municipal wastewaters at several places. In WSPs, removal of coliforms mainly depends on DO and pH which vary with season (summer/winter) and nature of the pond, i.e. anaerobic, facultative or maturation. Their removal is of concern as their presence indicate the possibility of the presence of pathogens. Discharge of wastewaters containing disease-causing microorganisms may result in water-borne diseases such as cholera and diarrhoea. Accordingly, a need was felt to study the removal of coliforms during summer and winter months at different stages (i.e. anaerobic, facultative and maturation) of a WSP based wastewater treatment plant (WTP). Thus, the objective was to scrutinize the fate of coliforms in WSP in different seasons and at different stages. A WSP located at Rishikesh working since last 29 years was selected. It consists of five ponds in series: one anaerobic, two facultative and two maturation. The Result being discussed here are based on the analysis of the samples collected once/twice a month from six locations in WTP from Sept. 2016 to Feb. 2018.

In summer and winter months, total coliforms in raw wastewaters were found to range from 2.3×10^6 to 3.3×10^8 and 2.2×10^6 to 2.8×10^6 MPN/100 mL respectively. In summer months, average removal of total coliform in anaerobic, facultative and maturation ponds were observed to be 0.4, 1.1 and 1.8 logs respectively. Contrary to this in winter months, average removals were found to be lower, i.e. 0.2, 0.8 and 1.0 logs respectively. This resulted in the overall removal of 3.3 logs in summer and 2 logs in winter months. Removal of fecal coliform and E-coli also followed the similar trend. Overall average removal of fecal coliform was observed to be 4.2 logs in summer and 2.1 logs in winter. In the case of E-coli, overall removal was observed to be 3.3 and 1.9 logs in summer and winter months respectively. It could be concluded that in a WSP based STP, major removal of total coliform, fecal coliform and E. coli takes place at the last stage, i.e. maturation ponds. Better removal takes place in summer compared to winter months mainly due to higher pH and dissolved oxygen content.

SDEWES2018.0577

Goefluentes Project: Promoting Energy and Nutrients Recovery from Pig Slurry at Farm Scale

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Abstract

Intensive livestock production is known to have considerable environmental impacts. GoEfluentes project's objective is to look at livestock effluents as a resource, focusing on the management of the different waste flows produced at farm scale. This work describes the preliminary activities developed during the first year of the project on energy recovery from pig slurry through AD. We characterized the selected pig farm in terms of practices and performance, particularly regarding slurry management. Results showed that slurry from growing/finishing phase had better energy recovery potential than from the CCPS. Therefore this slurry was used for AD lab scale trials in a CSTR under mesophilic conditions, aiming definition of optimal conditions for scale-up to farm level. Results indicate that it is possible to recover up to 378 mL CH_4 g_{VS}^{-1}, which is four times higher than the production with the CCPS (an average of 90 mL CH_4 g_{VS}^{-1}).

SDEWES2018.0593

Removal of Congo Red by Biosorption Onto Pleurotus Mutilus Biomass in Aqueous Solutions: Kinetic, Equilibrium and Thermodynamic Studies

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Abstract

The production of antibiotics in Algeria generates huge quantities of residual biomass that should be considered as a valuable biosorbent. This work is a contribution to the valorization of this biomass for the removal of Congo Red dye (CR). Therefore, the biosorption of (CR)by pleurotus mutilus biomass was studied in batch. Optimal conditions were determined by varying the biomass dose, initial dye concentration, pH solution, contact time and the temperature.

The maximum uptake capacity was found to be 27mg/g at a pH value of 3.5, for 1g/l of biosorbent dose, 50 mg/l of dye initial concentration; in a duration time of 180 min and a temperature of 300 K. Based on R^2 value, equilibrium isotherm data was best described by the Langmuir model than Freundlich, Temkin, Dubinin-Radushkevich models. The biosorption kinetics of (CR) removal using pleurotus mutilus was better described by the pseudo-first-order kinetic equation; the biosorption process is governed by an external mass transfer.

The thermodynamic parameters of the biosorption $\Delta G°$, $\Delta H°$ and $\Delta S°$ demonstrates that biosorption of (CR) by pleurotus mutilus is a spontaneous process and endothermic in nature. Globally, this work showed the high potential of pleurotus mutilus as a biosorbent for the treatment of water contaminated with Congo Red dye.

SDEWES2018.0634

Improving Waste Management in Developing Countries: Case Study Accra, Ghana

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Abstract

In this study the urban waste management system of Accra is used as a case study for analysing options to improve waste management systems in developing countries. Accra has similar infrastructure and waste management challenges as other major cities in developing countries. To achieve the study objective the current status of waste management in Accra needs to be investigated. Another aspect to be analysed is the existing (novel) technologies in waste management and if, and how they could be implemented in Accra. In deciding on the feasibility of these options for Accra the societal aspects of these waste management innovations are of utmost importance for their successful implementation: sanitation and hygiene are deeply embedded in societal cultures, and are socially defined. The focus in this study is on organic waste since this type of waste has high potential as raw material in sustainable energy production processes. About 66% of the waste in Accra is organic waste. Improving the waste management is not only a matter of creating and maintaining a technological system but also a matter of changing people's behaviour: making them aware of sustainability, environmental protection and public health issues. Education on sustainability, environmental protection and waste classification is recommended. Research is ongoing on organic waste separation technologies as well as on the use of small systems to convert organic waste into energy and the applicability of these systems in small communities.

SDEWES2018.0636

Impact of Rainfall Events on the Electricity Consumption of a Wastewater Treatment Plant

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Abstract

Focus on the Energy/Water Nexus has led to interest and increased research activity into various aspects of the relationship between water and society. Uncertainty in both the energy and water sectors going forward can only be reduced by improving the understanding and considering the inter-linkages between the two. To that end understanding the energy requirement of Wastewater Treatment Plants (WWTPs) will be a key focus. Using wastewater treatment plant data the aim of this paper is to study the relationship between the energy requirements for Wastewater Treatment (WWT), with particular focus on the impact of Wet Weather Flows (WWFs). It has been established from the literature that the efficiency of treatment plant processes drops during these events and, should treatment works be subject to increased energy requirements during WWFs, this will have an impact on any benchmarking effort. Using linear regression, a potential link is established between the catchment area rainfall and flows to treatment for two WWTPs in Northern Ireland, which was found to be consistent with previous work in the literature. Another possible link between these increased flows to treatment and electricity consumption of one WWTP has been shown, while no such link could be established at the second treatment plant and a possible reason for this is discussed. Another subject discussed is the question of whether the energy consumed by the wider collection systems should also be considered during any assessment or benchmarking exercises.

Energy and Environment

SDEWES2018.0138

The Potential of Nuclear Energy in Minimizing Greenhouse Gas Emissions: a Case Study from Turkey

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Abstract

Climate change caused by greenhouse gas (GHG) emissions due to anthropogenic activities threatens the sustainability of human existence on the earth. According to the IPCC, the increase in surface temperatures can reach up to 6.4°C by the year 2100 unless effective precautionary measures are implemented to minimize the emission rates and to find ways to decrease the increasing ambient concentrations. Nuclear power generation is now being discussed with regards to its potential in replacing the fossil fuel-based power generation, which is considered to be the one of the most important emitters of greenhouse gases. Consequently, serious debates are now underway in scientific and political arenas as to whether nuclear power can serve as a viable remedy to the increasing carbon emissions from fossil fuel-based energy generation techniques.

Although major GHG emitters of the world include countries like USA, China and India, Turkey can also be considered as a significant contributor with a total of 475.1 $MtCO_2e$ in 2015. Of this total, the majority of the emissions were determined to be associated with electricity generation from fossil fuel based power plants. Turkey has committed to decrease its CO_2 emissions following the approval of the Paris agreement and consider increasing the share of other power generation methods such as renewable sources and nuclear power. As of 2018, Turkey has no nuclear power plants and generate about 70% of its energy from coal or natural gas–fired power plants. However, there are plans on constructing two plants (Akkuyu and Sinop) in southern and northern coast lines along the Mediterranean and Black Sea, respectively.

Based on this background, this study intends to assess Turkey's position in the global GHG emission platform with possible predictions for the year 2030 and further aims to demonstrate the changes it could achieve by introducing nuclear power to its energy generation portfolio. For this purpose, predictions of energy generation and its distribution among alternative sources are discussed, forecasts on associated GHG emissions are made and possible reductions that can be achieved with the introduction of nuclear energy are evaluated in an integrated manner. Finally, the results are further discussed by considering potential environmental consequences.

SDEWES2018.0169

Life Cycle Sustainability Assessment of Tertiary Buildings: a Review of the Social Performance

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Abstract

Buildings' life cycle sustainability assessment is composed by environmental, economic and social aspects evaluation. Environmental and economic assessments have long record, while buildings' social performance analysis is still under development. Standard UNE 15643-1:2012 stablishes the general framework for buildings' sustainability assessment, leading to, in the case of social performance, UNE 15643-3:2012 and UNE 16309:2014+A1:2014, at framework and building levels, respectively. However, regulation and policies at European, national and local level, are already on-going in a disaggregated way.

Non-residential building stock stood for one fourth of European Union buildings, considering a total of buildings' useful floor space of almost 30,000 Mm^2 accounted in 2013, whereof about 30% was represented by wholesale and retail sectors' building stock. The fact that tertiary buildings' are heterogeneous and, usually, open to general public and/or to occasional visitors, calls for major efforts towards users and society appropriateness. Architectural barriers and risks have previously been detected with regard to, for example, substance inhalation, cumulative layers of noise and lack of universal accessibility, which goes beyond ergonomics.

A review of the social performance of tertiary buildings, according with UNE 16309:2014+A1:2014, is developed in this paper. With regards to the building's use phase, the relevance of the following performance categories are analysed in food retail stores as a case study: i) accessibility, ii) adaptability, iii) health and comfort, iv) impact on neighbourhood, v) maintenance and vi) safety and security. In addition, a qualitative evaluation of the implication in the results towards the three main stakeholder categories, namely i) users, ii) neighbourhood and iii) society, is included. For this purpose, a holistic approach is suggested from a life cycle point of view, which can then be aggregated to environmental evaluation. Thereupon, through a comprehensive background assessment, this communication presents a methodological review and framework approach towards tertiary buildings' social performance evaluation, underscoring this typology's features, conducting a bibliographic and usual practices evaluation and proposing a systematization procedure.

SDEWES2018.0196

Opportunities for Power-to-Hydrogen in CO2-Reduced Energy Scenarios: the Italian Case

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Abstract

Integration of renewable energy in the electricity market poses significant challenges on power grid management due to the volatility of these sources. In fact, the mismatch between renewable energy power generation and load curves, along with the need for grid stability, may lead to substantial curtailment when potential power generation exceeds electricity demand. In this respect, the surplus from renewable energies can be exploited to produce hydrogen via electrolysis. This concept is referred to as “Power-to-Gas”, often further categorized as “Power-to-Hydrogen”, and is rapidly emerging as a promising measure in support of a renewable energy penetration that allows the decarbonisation of energy generation without affecting grid reliability.

This study evaluates the impact of Power-to-Hydrogen systems on future CO_2-reduced scenarios, characterized by increasing shares of renewable energies and electric vehicles. Results assess the synergy between power-to-hydrogen technology, renewable energy penetration and sustainable mobility in terms of CO_2 emissions, curtailments and costs.

SDEWES2018.0391

Enhanced Oil Spill Remediation by Selective Adsorption with Graphene-Based Materials

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Abstract

An oil spill event can cause a multitude of issues for human health and environment. Disasters such as the Deep Water Horizon explosion and Exxon Valdez incident provide evidence that oil spills pose danger to the economy and natural resources.

Sorbent materials can provide a useful solution in response to oil spills, allowing oil to be removed in situations that are unsuitable for other techniques but the emergency management is usually affected by a large consumption of materials and high operative costs. Moreover, sorbents effectiveness should be as high as possible in order to minimize the amount of waste that can greatly increase the costs of a response. On that basis, materials with high adsorption capacity represent a resource for oil spill remediation improving.

In this study, the Grafysorber® (Directa Plus S.p.A), an innovative super-expanded graphene-based material, was investigated via field applications on a real contaminated site. Several experimental tests were performed using Grafysorber® inside adsorbent devices (booms and pillows) to treat waters polluted by oil. The experimental campaign was carried out with the aim to compare Grafysorber® performances with those of the PP, which is the material used worldwide in case of water oil spill clean-up activities.

The results achieved have confirmed a considerably higher selective adsorption capacity of Grafysorber® compared to PP, and configure the new material as a promising alternative to standard materials in enhancing oil spill remediation by selective adsorption.

SDEWES2018.0573

Is Installing Large Renewable Capacities Enough to Decarbonize the Coupled Electricity-And-Heating System in Europe?

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Abstract

In order to transition towards a European energy system that is compatible with a maximum 2°C temperature increment due to climate change, one of the key questions is how to plan and operate it to integrate large amounts of Variable Renewable Energy sources (VRES). Increasing transmission capacities among European countries facilitates the integration of geographically dispersed VRES. An additional strategy consists in coupling the electricity with other sectors and take advantage of the synergies provided by this local interconnection. We have investigated the combined effects of both strategies with an open hourly one-node-per-country network model, PyPSA-Eur-Sec-30, where the electricity and heating sector are coupled. The joint capacity and hourly dispatch optimization finds the cost-optimal system configuration subject to constraints such as supplying inelastic hourly demand in every sector. The VRES generation in every country is assumed to be proportional to its average total demand, that is, European countries are considered self-sufficient while decarbonizing their energy systems.

The optimal system configuration is investigated for large parameter sweeps such as the VRES penetration, the wind/solar mix or the price for CO_2 emissions. This allows us to determine that to decarbonize the coupled electricity-and-heating system it is not enough to follow an ambitious path to install renewable capacity, but a minimum CO_2 price is required to force the gas out of the system. Otherwise, a less efficient system where renewables are curtailed and gas is still used is more cost-effective. To achieve a 95% CO_2 emission reduction, relative to 1990 level, a CO_2 price equal to 380€/tCO2 has been identified. Since no biomass to produce electricity is included in the model, the CO_2 price must be high enough to alter the merit order between an expensive supply of heat through power-to-heat technologies and a cheap use of gas for heating. Furthermore, the CO_2 price shows a flat optimal area, indicating that alternative system configurations can be selected to achieve the CO_2 reduction target. For the optimal system configuration, the residential and service heat demand is supplied mostly by heat pumps, while resistive heaters and gas boilers are used to cover demand peaks.

SDEWES2018.0586

Reaction Mechanism on Denox by Vacuum Ultra Violet Irradiation

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Abstract

Emission of nitrogen oxides (NO_x) from stationary combustors and ship diesel engines has been regulated for environmental pollution control and public health. Selective catalytic reduction (SCR), an efficient treatment technology, has been used world-wide for NO_x removal in large-scale combustors such as coal-fired power plants. In SCR systems, nitric oxide (NO) reacts with injected molecular ammonia in the presence of a catalyst and oxygen at a temperature of around 350 °C at which NO converts to molecular nitrogen and water. A drawback of SCR systems in application to incinerators and ship diesel engines is that they are particularly costly because frequent replacement of the catalyst is required owing to catalyst poisoning by sulfur dioxide, plugging and erosion by ammonium bisulphate, and deposition of ash, amongst others.

We have been developed an original deNO_x reactor using vacuum ultraviolet (VUV) of 172 nm wavelength. The advantages of the deNO_x system are no catalyst, ammonia free and low temperature reaction. The photochemical reactor using the VUV may be able to apply to waste incinerators and ship exhausts.

In this study, reaction mechanism of deNO_x by the VUV were investigated to find a rate-controlling reaction step. The rate constants of photochemical reactions were measured in NO/N_2, NO_2/N_2, $NO/O_2/N_2$, and $NO/O_2/H_2O/N_2$ gas systems using a VUV photochemical reactor. The photochemical reactor had an inner diameter of 80 mm, and the length was 100 mm. An outer diameter of the excimer lamp was 40 mm, therefore, the gap length between the lamp and the inner wall of the reactor was 20 mm. The power density of the VUV lamp was 27 mW/cm^2 at the lamp surface.

Some elemental reactions on deNO_x by VUV irradiation were suggested by experimental results. The reaction mechanism were verified by elemental chemical reaction simulation using CHEMKIN. The simulation results were good agreement with the experimental results. The reaction rate constant and the reaction mechanism on deNO_x by VUV irradiation were elucidated.

Buildings

SDEWES2018.0139

Energy Savings in University Classroom Using Different Lighting Control Systems

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Abstract

The amount of energy consumed by school buildings is rising faster than the total energy consumption in South Korea. Given that lighting energy accounts for a high percentage of 23.9% of the power consumption of university buildings, lighting energy saving is expected to contribute to the reduction of the total power consumption. Representative control systems for lighting energy saving include occupancy based lighting control and daylight harvesting systems. The energy saving effect of these systems varies greatly depending on the occupancy patterns and the application environments. Therefore, the purpose of the present study is to understand the energy savings appearing when the lighting control systems are applied to the profile of actual lecture rooms. The actual occupancy patterns and lighting operation schedules were derived based on videos taken for one week by the CCTV in a lecture room. Through numerical simulations based on the actual occupancy patterns and lighting operation schedules, the amounts of lighting energy used in four scenarios were calculated. The results showed lighting energy saving rates in a range of 3-47% according to the scenarios based on the situation in which the actual schedules were derived.

SDEWES2018.0301

Control Systems for Indoor Lighting and Computer Simulation: Analysis and Comparison Between Software Capabilities and Results on a Real Case Study

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Abstract

In the last years, computer capabilities have evolved rapidly and also the way to simulate building physics phenomena is changed and more developed. Each simulation software is developed with a less or more similar aim, using different algorithms and models and being used by people with different profile: specialist, architects, engineers, installers, etc. This paper deals with the analysis of capability of some of the most utilised software used to predict indoor lighting, including natural daylight contribution and assessment of energy consumption and savings related to specific design options. Furthermore, two of the analysed software have been tested simulating a case studying. Results show that data calculated by different programs can be very dissimilar. Moreover, consumption calculated using the same software (i.e. Dialux), but using methods proposed by two different technical standards can be very different. It obviously means that while approaching an energy study of a lighting set up, it is necessary to do an accurate selection of the tools to be used, and it is necessary, as well in this case, to analyse critically the results.

SDEWES2018.0495

Experimental Validation of a Dynamic Building Energy Simulation Tool and Case Study Analysis on Low-Emissivity and High-Reflective Coatings

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Abstract

This paper presents the experimental validation of a novel in-house building energy performance simulation tool and a case study analysis on low emissivity and high reflectance materials. The developed tool (called DETECt) was conceived for research purposes with the aim to analyze the energy performance of innovative building envelope technologies and plant systems and to predict the whole building thermodynamic behavior. The simulation model, based on thermal network approach and implemented in a computer code written in MatLab, allows one to properly model the emissivity of the indoor surfaces and their spectral solar reflectance, necessary to predict the thermal behavior of low emissivity and high reflectance materials. In order to confirm and ensure the reliability of the in-house developed calculation tool, a suitable empirical validation was carried out. Such procedure was performed by comparing simulation results to measurements obtained from a real test room, built up by standard materials and exposed to natural environmental conditions. Details about the experimental campaign and the successful empirical validation of DETECt are reported in this paper.

Finally, to show the potentiality of the building model, a case study analysis relative to different low-emissivity plasters for interior spaces and cool paints for external surfaces is presented. By using the validated experimental model, capable of modelling variable properties of outer surfaces of the building envelope and low-emissivity of internal ones, a comparative analysis is carried out to evaluate their impact on the thermal dynamic behaviour of the test cell and to assess its heating and cooling demands. Both passive envelope strategies, also coupled together, show potential to reduce building heating and cooling demands compared to standard finishing.

SDEWES2018.0526

Determination of a Short Simulation Sequence for the Multi-Criteria Optimization of Buildings: Bibliographic Study and Perspectives

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Abstract

Holistic approach is considered important for building design optimization, taking into consideration all the decision parameters playing a role on its performance. However, models become complex when considering the envelope and the systems linked to it thus leading to unfeasible computational time expenses. Usually, this issue is overcome by proposing alternative simplified or reduced models, which represent the real complex one. Other approaches include performing parallel calculations or using meta-models such as artificial neural networks or kriging models. A new holistic approach based on the reduction of the time of simulation ("time series aggregation" or "representative days' selection") is a current subject of interest in the field. The following paper presents a review on the approaches used in the literature for typical day selection and their use in the field especially in optimization studies. It was found out that the approaches could be classified into three main categories: Heuristics, Iterative and Grouping algorithms. A detailed discussion was made on the limitations and efficiency of the approaches in each category and on their preference of use. Optimization by short sequence was also analyzed and the contributing studies were presented. Tests in the literature showed good coherence between the predicted and original results with a remarkable time reduction. Finally, conclusions and perspectives were conducted on how to improve this domain of study to encourage its use in the field.

SDEWES2018.0556

The Challenges for Energy Efficient Public Buildings in a Depopulating Mediterranean Region: a Gis-Based Support Tool

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Abstract

The aim here is to provide a simplified Energy Efficiency (EE) assessment tool which, based on the information provided by the Energy Performance Certificates (EPCs), analyses potential EE measures in terms of costs and economic savings, providing an estimation of the payback time. The tool is open-source and based on a Geographical Information System (GIS) so that buildings are geographically presented. Considering the building status, the tool provides potential EE measures to reduce the energy consumption and associated costs, applied to the envelope, HVAC and lighting systems. Results provided include, among others: updated energy losses, associated costs, CO_2 emissions and non-renewable primary energy, as well as energy, economic and CO_2 emission savings compared to the current status. Finally, capital cost and payback time are estimated. Among other users, this tool can be employed by public authorities and energy agencies to estimate the impact of potential EE measures at regional or national levels, and serve to analyse where energy savings potential is the greatest, for instance, to assist in the design of financial support strategies. Additionally, public authorities can use it as a starting point for the preparation of the energy plans.

SDEWES2018.0612

High Performance Building Plasters with Retro-Reflective Microspheres

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Abstract

RR materials are a particular type of cool materials able to reflect the solar radiation mainly toward the incident direction. For this reason, these materials are used in deep urban canyon to reduce the heat trapped inside and to mitigate the Urban Heat Island (UHI) phenomenon. This paper introduces new plasters for outdoor applications with RR optic properties. The paint has been obtained through deposition of four different types of RR microspheres on a traditional plaster for exterior applications. The plasters have been characterized according to: i) spectrophotometric analysis ii) the angular reflectance analysis iii) colorimetric analysis. The goal is to investigate the opportunities and potentialities of RR materials compared to common materials for building envelope through an analytical model specially developed. All the types of microspheres provide strong RR behavior for incident light directions from 0° to 60° with respect to the surface normal. However, the aluminum coating, with and without fluoropolymer coating, affects negatively the global reflectance and change completely the tiles' original color, making the application of the aluminum RR tiles very limited. Clear barium microspheres instead improve the optic properties of the original tiles, with negligible effects on the color.

Energy efficiency

SDEWES2018.0082

A Comprehensive Sensitivity Study on the Performance of the Multi-Effect Distillation Technology

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Abstract

The multi-effect distillation (MED) technology is widely used in the seawater desalination sector and is particularly attractive whenever the raw feed is characterized by very high salinity and challenging seawater quality, or in the case low cost waste heat is available. To this adds a stable and relatively simple operation in comparison to reverse osmosis (RO). Despite these advantages, RO is nowadays the preferred option for seawater desalination, which is mainly due to dramatic enhancements in the membranes performances and the reduced energy requirements. In contrast to these applications, in which the main product is the distillate, in some other cases (e.g. preparation of regenerant solutions for ion exchange (IEX) units) the most valuable product is the concentrate stream, also called brine, while the distillate is considered a by-product. This paper presents a comprehensive sensitivity study on design parameters (i.e. amongst others top temperature, gain output ratio -or GOR- and number of effects) as well as on economic parameters for these two applications, highlighting similarities and differences in the respective optimal configurations. In addition, different possible layouts, namely forward-feed and parallel-cross are discussed and compared. Finally, the impact of the introduction of a thermal vapor compression (TVC) on the results is assessed.

SDEWES2018.0197

GfK Data on Energy Efficient Appliances Sold in Germany – Is the Market Shifting Towards Top Runner Products, Which Role Does the EU Energy Label Play and What Is Important for the Consumer?

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Abstract

Motivation

A refrigerator can be found in more than 99 per cent of the country's approximately 40 million households - and there are numerous further appliances connected for several hours each day to the network. There is an enormous potential for energy savings, if as many households as possible switch to energy efficient electric appliances. To reach this goal, the German Federal Ministry of Economic Affairs and Energy (BMWi) launched the "National Top Runner Initiative (NTRI)" in January 2016.

The NTRI is intended to bring energy efficient and high-quality appliances (so called top runners) onto the market more quickly, thus accelerate market replacement. For this purpose, motivation, knowledge and competence in product-related energy efficiency is to be strengthened and expanded along the whole value chain - from the appliance manufacturer to the retailer and the consumer. Consumers get valuable information about top runner products and how they can benefit. Therefor the GfK selling data of refrigerators, televisions and lighting products in Germany will be evaluated. The findings will be analysed and used to develop user specific material on the key issues.

Major results

For TV sets, there has been a trend towards larger screen diagonals for years. This is causally linked to a change in technology from tube technology to flat screens.

The demand of refrigerators and freezers is increasing. In 2015 2.4 million devices were sold and the trend is ever increasing. The size of the refrigerators and freezers is increasing from year to year as well. At the same time, power consumption per unit decreased significantly.

Sales of light bulbs have levelled off with some 80 million units sold per year for several years in Germany. The EU Ecodesign Regulation have lead significant changes in the market shares of various lighting products in recent years.

Conclusion

The market is shifting towards top runner products regarding the product groups of refrigerators, televisions and lighting. But there is also potential lost due to growing product sizes and add-ons, which lower the gain in energy efficiency that could be achieved. Tailored information material is necessary to strengthen the good effects of EU Energy Label and Ecodesign Directive.

Therefor NTRI developed different tools, such as various videos, quizzes and haptic materials to spread the information. In addition a product finder, an online label pilot and education material for salesmen were designed.

SDEWES2018.0448

Optimum Increase of Heat Recuperation Capacity in Existing Two-Stream Heat Exchange Systems

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Abstract

Almost all currently operating plants using chemical-technological methods for the production and processing of raw materials and products are energy-integrated systems. In many of them, cold raw materials are heated by the product leaving the unit. If it does not heat up to the required temperature in the heat exchange system, then the process furnaces or steam heaters are used for its further heating. Similarly, if the effluent does not cool to a predetermined temperature, it is cooled in water or air coolers. Such systems are encountered in the process of visbreaking and hydrofining in oil refining, in the distillation of coal tar, in the production of benzene in coke chemistry, in petrochemical processes and in the food industry. To reduce energy consumption during heating of raw materials, it is necessary to increase the heat recovery capacity in existing heat exchange systems, and to do this at the lowest cost.

In this paper, the task of economically optimal increase in the heat recuperation capacity is solved by installing an additional heat exchange surface in a two-stream heat exchange network with an arbitrary number of existing heat exchangers.

To solve the problem, the equations of thermal balances for each process flow, each heat exchanger and the ratio for calculating the area of heat exchange power in existing and new heat exchangers were used. Thermophysical properties of heat carriers were considered to be constant. As a result, the heat carrier temperature dependences in existing and new heat exchangers, their thermal loads and thermal loads of utilities on the heat exchange surface added, or on the thermal load on the new heat exchangers were obtained. This load can be determined both by the value of the heat exchange surface and the intensity of heat exchange.

The obtained results are used to optimize the project retrofit of the heat exchange system in the process of light hydrocracking. The values of the additional surface area of the heat exchange, which is necessary for the minimum present cost of the heat exchange network retrofit and for the minimum payback period of the retrofit project, are determined. It is shown that, with existing technical and technological limitations on the unit, it is advisable to install an additional heat exchange surface on the hot side of the heat exchange system. In the proposed reconstruction project, the capacity of the hot utility will be reduced by 50%, and cold by 30%.

SDEWES2018.0458

Simulation, Performance Evaluation and Energy Optimisation of an Existing Crude Oil Distillation Unit: a Case Study from Refining Industry

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Abstract

Crude Distillation Unit (CDU) represents significant challenge for retrofitting and energy optimization as the most intensive energy consumer in a conventional crude oil refinery. Pinch Technology and its based-methodologies are found primary keys for decades to energy savings in refining industries for a range of common economic-based and environmental objectives or applications. Typical benefits in energy savings are reported within 20 to 40% of original designs. However, such savings are limited and questioned when modern refiners are dealt with. The current paper addresses the revamping of a modern refinery exhibiting an existing high energy efficiency (≈93%). This implies the maximum potential energy savings would be 7% at current process conditions. The present research proposes an algorithm to tackle energy savings of modern refiners to target an energy saving level beyond the energy targets set by the existing process. The algorithm starts by process simulation and validation against real plant data. Then, a network optimisation is conducted, e.g. stream splitting, to reach the energy targets set by the Pinch Analysis Principles. The energy targets are then moved to another lower level by performing some potential process modification. Afterwards, modifications are implemented to reduce the energy consumption further. Results showed that the current modern refinery unit can reach its energy target by stream splitting modifications with energy savings of 7%. Process modifications resulted in an extra saving of 31% beyond the current level of existing plant. Comparable reductions were obtained with respect to CO_2 emissions, with reduction in emissions by 45.1%.

SDEWES2018.0576

Investigation of Thermoelectric Modules for Heat Pump Application

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Abstract

Increased quality of building envelopes in the last decades leads to decreased heating demands of new buildings and therefore heating devices with lower heating powers are needed. There is a lack of suitable solutions in the heating market in the small power range, which can cover small heating loads decentral without distribution losses. A heat pump based on the thermoelectric effect is able to cover this market area. With the thermoelectric effect, it is possible to pump heat from a low to a high temperature level, whereby the entropy transport of the moving electrons is utilized. The big advantage here is the absence of any climate-relevant gas for operation. In addition, thermoelectric modules, also called Peltier elements, have no moving parts, so that they can run almost maintenance-free. However, a disadvantage is the relatively low efficiency of these elements. On the market a variety of Peltier elements are available, with a price ranging from few euros to over 100 euros per piece. In order to get an overview of the quality of diverse Peltier elements, a test bench for efficiency determination was designed and built. In a first test bench configuration, insulating material was used to prevent heat loss to the environment. To increase the accuracy of the measurements, tests were additionally carried out in a vacuum chamber at a pressure value below 10^{-4} mbar in order to avoid heat losses through convection. Infrared-reflective foils have been used to prevent heat exchange with the environment by radiation. In the actual study the influence of convection is represented by a comparison of the measured data from tests in vacuum and in air. In detail, the change of the calculated Seebeck coefficient, the thermal conductivity and the ZT value was considered. Based on the results, a selection can be made which Peltier elements are promising candidates for the installation in a heat pump.

SDEWES2018.0582

A Study on the Lighting Energy Consumption According to Occupants Behavior Result Using Energy Feedback Visualization

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Abstract

Energy consumption of public buildings such as university buildings is increasing every year. Therefore, research for energy conservation of public buildings is needed. Therefore, this study to investigate the effect of energy conservation using energy feedback on the lighting energy consumption of public buildings. Previous research has shown that energy feedback has a positive impact on energy conservation globally, affecting the renewal of energy feedback in Korea. The research on energy feedback has been going on continuously and further research is needed in the future. Therefore, in this study, we try to examine how energy feedback visualization affects occupant behavior and how occupant behavior affects the amount of lighting energy consumption. To do this, we measured the lighting energy consumption behavior of the university lecture room, which is one of the public spaces, for 6 days. The first three days were measured to derive the existing lighting energy consumption patterns. In the following three days, different energy feedbacks were used to measure lighting energy consumption behavior. At this time, energy feedback was experimented with 'Nudge feedback' and 'General feedback'. The lighting energy consumption was calculated from the experimental measurements. After the experiment, additional surveys were conducted to survey the impacts and priorities of energy feedback. Experimental results show that 'general feedback' is more influential than 'nudge feedback'. In addition, the survey results showed "general feedback" is more influential. And as a result of what factors are given priority in feedback, position was 44%, followed by design, shape 20% and size 18%. In addition, the calculation of lighting energy consumption using classroom experiment data showed that 'Nudge feedback' was reduced by 2% and 'General feedback' was reduced by 25%. Therefore, in the future, research is necessary diversify the feedback method and reflect the important factors in feedback.

Heating and cooling

SDEWES2018.0113

Thermoeconomic Analysis Under Dynamic Operating Conditions for Space Heating and Cooling Systems in Small Residential Buildings

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Abstract

Due to the social concern for energy savings and ecological improvement necessity in the performance of buildings, new analysis tools emerged.

Thermoeconomics connects the physics and economics of energy conversion processes through the second law of thermodynamics. A limited number of thermoeconomic applications in buildings have been proposed, due to the difficulties in dealing with very irregular energy load profiles and unsteady plant operating conditions, which require the use of dynamic approaches that increase the complexity of the method. The present study highlights the potential of thermoeconomics as a support for decision making, due to the capability to identify trade-offs between cost and efficiency. Dynamic thermoeconomic analysis is performed for a school dwelling, supplied with space heating and cooling integrated with a mechanical ventilation Air Handling Unit.

The different sources of irreversibility are evaluated and the main targets for system improvement are identified, calculating exergetic, exergoeconomic and exergoenvironmental costs.

SDEWES2018.0142

Determination of an Thermal Comfort Zone for Personalized HVAC Control

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Abstract

Innovative HVAC system should be able to perform not only energy savings but also adequate operation taking into account the health or emotional state of the occupant. In the personalized HVAC system, the thermal comfort zone of resident is the main factor for determining the operating schedule and set value of the heating, ventilation and air conditioning system.

In this study, the possibilities and limitations of existing methodologies for determining personalized comfort were discussed. Various previous studies that attempted to address such limitations were organized. Among them, we used a method to substitute the metabolic rate (MET), which is a personal element of the predicted mean vote (PMV), with the heart rates obtained using a wearable device. We propose a model that approximates the actual sensation vote (ASV), which is the thermal comfort response of the actual occupant, through the scale correction of the PMV using the MET substituted with the heart rate.

SDEWES2018.0148

A Study on an Optimal Control Method to Control HVAC Systems to Energy Saving in the Office Using a Control Algorithm

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Abstract

As our society is entering an era of knowledge industry, the increased length of time spent in offices has also led to an increase in energy consumption. Research needs to be conducted on energy use in offices that continues to increase when energy saving measures are necessary. In this study, office HVAC systems are controlled in winter using a control algorithm in which comfort standards for temperature and PMV components have been established. Using the HVAC systems operation patterns and changes in the components of the thermal environment, which can be calculated through the control, their correlations are analyzed based on occupant comfort. The analysis results are then used to suggest an optimal control method to control HVAC systems to energy saving in the office and improve occupant comfort. The experiments were carried out at selected offices in South Korea, where ERV systems were installed. The test equipment was installed in each office to collect the data. To determine occupant comfort, copies of the questionnaire prepared based on the ASHRAE 7-point thermal sensation scale were distributed. The experiments were performed for a total of three days on the control group, where the patterns of daily office life were recorded, and the experimental groups where temperature and PMV were controlled. The results show that the control and the PMV-controlled group produced identical values in the amount of operation of the heating system and thermal sensation. However, in the PMV-controlled group, thermal sensation exhibited a great difference between the maximum and minimum, and many respondents said “hot” towards the end of the experiment. This is presumably because the PMV control did not take into account the ability of the occupants to adapt to the heat. The overall operation patterns of the HVAC systems revealed that the temperature-controlled group showed lower energy consumption with the lowest amount of operation, but also simultaneously the lowest level of comfort. In sum, the results of the study suggest that comprehensive control standards encompassing both temperature and PMV components should be suggested, instead of choosing one of the thermal environment components to control office HVAC systems.

SDEWES2018.0156

Accounting for Cllimate Change-Induced Change in Space Heating Demand in Energy Systems Optimisation: Case Study of Denmark

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Abstract

The heating demand in the building stock represents significant part of the total energy consumption in Denmark. The development of the heating demand depends on the construction and demolition rates, energy efficiency standards of newly built and renovated buildings as well as behavioral factors. These factors are frequently incorporated in energy system models. The factor which has the major influence on the future heating demand is the outdoor temperature. This development of the outside air temperature is very uncertain, but it is very unlikely that today's temperature patterns will remain the same in the long-term horizon. The underlying assumption in the most of energy system models is that the outside temperature remains constant; even in the analysis until 2050. The Danish experience is that every 1 degree Celsius increase reduces the heating demand by 7%. In this study we focus on accounting for the climate change-induced change in space heating demand in buildings. We use the CORDEX database to derive the change in heating demand in Denmark until 2050 under RCP2.6 and RCP4.5 greenhouse gas concentration trajectories. This data is then used in a multi-sectoral energy system optimisation model TIMES-DK to analyse the effects of accounting for the change in space heating demand under a "Frozen policy" and "Fossil-free Denmark" scenarios until 2050.

SDEWES2018.0402

A Numerical Model for the Design of a Climatic Chamber

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Abstract

In the present paper, we develop a numerical analysis supporting the design of a climatic chamber suitable for tracked and wheeled tractors, i.e. having measures 5x8x4 m^3 (length x width x height).

The numerical analysis is performed by employing Matlab-Simulink, to simulate the behavior of transient systems. First, the balance equations are written with reference to the 5 blocks that can describe the climatic test chamber. Then two different regimes are investigated. First, a period of 10 hours is considered in order to reach the prescribed conditions for the climatic test chamber. Then, after this preparation period, the tractor's engine is supposed to work.

The performed analysis has shown that higher values of the adduction coefficient are preferable. Moreover, the dynamical analysis turned out to be a very useful instrument to drive the design.

SDEWES2018.0575

Review of Alternative Heat Pump Technologies

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Abstract

One possibility to reduce climate-relevant refrigerants is the use of alternative heat pump technologies, which operate without climate-damaging refrigerants. In this work, three different alternative heat pump technologies are considered. These include the thermoelectric, magnetocaloric and thermoacoustic heat pumps. Research activity over the last 20 years has been reviewed and several prototypes have been compared in terms of temperature difference and the coefficient of performance (COP). It turned out that the thermoelectric heat pump is the most researched technology and is currently used commercially in niche areas. The prototypes of the magnetocaloric heat pump operate at almost the same temperature difference as the thermoelectric heat pump. The thermoacoustic heat pump works at higher temperature spread. Currently, alternative heat pump technologies are not a replacement for conventional compression heat pumps in terms of energy efficiency. Therefore, in the immediate future alternative technologies will not contribute significantly to the reduction of climate-relevant refrigerants.

Thermal power plants and environmental impact of power generation systems

SDEWES2018.0040

Improving the Performance of the Gas Turbine Cycle Using CO2-Argon-Steam Oxy-Fuel (Carsoxy) as a Working Fluid in the Combustion Process

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Abstract

Heightening demand for electricity produced from fossil fuel-fired gas turbines has recently led to a sharp increase in CO_2 and NO_x from electrical generation plants. The excessive emission of these pollutants has contributed to the serious problem of climate change with its inherent consequences of global warming. Thus, new cycles using alterative gases have been proposed across literature. For example, one way to reduce emissions is to use an alternative to air as working fluid in the combustion process inside gas turbines, thus mitigating the production of NO_x emissions with further CO_2 capture/recirculation.

In a previous paper, it was proposed that CARSOXY, a novel blend that could replace air as a working fluid, could be efficiently used in gas turbines. This particular blend was conceptualised from the combination of various technologies (e.g. Carbon Capture and Storage (CCS) integrated with Oxy-fuel combustion and Steam Injection) using 39% Argon, 23% H_2O, and 29% CO_2 with methane as a fuel for gas turbine combustion. However, the efficiency and reliability of this modified cycle are still the main challenges to use CARSOXY as a working fluid for negligible NO_x formation with CO_2 recirculation.

Therefore, this paper uses Aspen-plus v.10 to calculate the total efficiencies and outputs power in each of three different cycles using gas turbines: 1) with methane/air, 2) with methane/air combined with water injection, and 3) the modified cycle using methane/CARSOXY. The same operating conditions and mass flow rate were considered for all cycles.

Results show that the total efficiency of the modified cycle working with methane/CARSOXY is around 10% higher than that obtained from the humidified cycle running with methane/air. Moreover, the efficiency of the methane/CARSOXY cycle increases by around 18% in comparison with the cycle using air as a working fluid.

Therefore, the CARSOXY blend could be employed as a working fluid instead of air in the modified cycle. Furthermore, because N_2 is not included in the combustion process, the CARSOXY blend can help to preserve a clean global environment by eliminating emitted NOx. Moreover, avoidance in the formation of nitrogen oxides ensures that CARSOXY can be used with simpler technologies such as diffusive fuel injection, thus limiting the unstable regimes during the combustion process. Additionally, CO_2 could be reduced by recycling a higher proportion of this product through the cycle in the combustion process, opening the possibility to employ CO_2 from other industries.

SDEWES2018.0470

A Parametric Study on Turbulent Agglomeration of Particulate Matter in Coal-Fired Power Plant

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Abstract

Turbulent agglomeration of fine particles is becoming an increasingly attractive technology because of the growing limits for particulate emissions from coal-fired power plants. In this work, based on Eulerian multiphase model and Population Balance Equation, a numerical model of turbulent agglomeration of particulate matter was established to predict the particle size distribution of flue gas particulates and applied to simulate a novel particle agglomerator from a 330MW coal-fired boiler by considering particle transport, collision behavior and coagulation efficiency. The model validation was conducted by comparing the simulated values with the field test data, and the result fitted well. Furthermore, the effects of four parameters (i.e. inlet velocity, particle concentration, longitudinal pitch, and arrangement) on the particle size distribution were investigated. The results showed that the removal efficiency of PM_1, $PM_{2.5}$ and PM_{10} presents a logarithmic curve with the increase of inlet velocity or particle concentration, respectively. The inlet velocity of particle agglomerator should be kept in a reasonable range (i.e. 11~15m/s in the study). For coal-fired power plants with a particle concentration of 17~68g/Nm^3, the removal efficiency of the particle agglomerator for PM_1, $PM_{2.5}$ and PM_{10} is 18%~53%. Considering the influence of longitudinal pitch on pressure drop, turbulent dissipation rate and vortex structure, an optimal value of 25~50mm is suggested. The effect of aligned arrangement is slightly better than that of the staggered arrangement for the particle agglomerator. The particle agglomerator with optimal designed structure is also well suitable for processing the flue gas with high concentration of particles in industries.

SDEWES2018.0471

A Study on Optimal Environmental Shutdown of Coal-Fired Generators for Greenhouse Gas Reduction

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Abstract

After the Paris Agreement in December 2015, research on greenhouse gas(GHG) reduction has been actively conducted worldwide. In South Korea, studies are underway on the regulation of coal-fired power plants, one of the major causes of GHG in order to reduce not only GHG but also find dusts occurring mainly in spring season.

Most of coal-fired power plants in Korean Power Market are base load power stations. So, if the generation of coal-fired generator is restricted, System Marginal Price(SMP) would be jumped, which is likely to be passed on to consumers. Therefore, optimization is essential for the dispatch restriction of coal-fired power plants.

Generally, dispatch restriction is tractable if they are implemented in a way that reduces the maximum output of generators. But, due to the characteristic of generators, limiting the output of generator reduces the utility and efficiency of the generator.

Therefore, we propose the environmental shutdown method, which is the way that shutdown of generators on specific dates rather than reducing the output of coal-fired power plants during the entire horizon. Environmental Shutdown is formulated similar to generator maintenance schedule and determines the most economical coal-fired generators shutdown plan that meets GHG emissions constraints as follows:

First, a sensitivity analysis of the power market is used to determine the appropriate number of shutdown days to meet the GHG emission constraints. Second, the optimization of shutdown scheduling is performed using the objective function, leveling the reserve margin ratio.

We apply the proposed method to the Korean actual power system and analyze the results. As results of this study, we expect to contribute to the power market generation scheduling that satisfies the GHG emission.

SDEWES2018.0479

Parametric Study of Carbon Dioxide-Argon-Steam Oxy-Fuel (Carsoxy) Gas Turbines

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Abstract

The aim of this paper is to conduct a parametric study for five gas turbine cycles (namely; simple cycle, heat exchanged cycle, free turbine & simple cycle, evaporative cycle and humidified gas turbine cycle) using a CO_2-Argon-Stem mixture as the working fluid in order to identify their ultimate working conditions with respect to the cycle efficiency and specific work output. The performance of the five cycles using CO_2-Argon-Stem has been estimated for wet and dry compression. Results for the mixture have been compared to results for Air. The ultimate cycle has been suggested for each range of working conditions. This paper also attempts to studythe effects of the molar fractionsof CO2, Argon and H_2O on the heat capacities in the compression and the expansion stages for a range of temperatures. The results have been reproduced for specific(CARSOXY) blends, which have been found in the literature to validate the adopted analytical approach. In addition, a new blend has been suggested which has theoretically shown a higherperformance.The paper provides a MATLAB codewhich has been developed to conduct the cycle analysis for the (CARSOXY) gas turbines.Assuming the stoichiometric condition of an equivalence ratio of 1,the produced results via the code are based on the higher heating value (HHV) of Methane combustion. The parametric study has been conducted to produce results in a three-dimensional surface rather than two dimensional curves, in order to consider the combined effects of two variables such asthe inlet temperature and pressure ratio.In this paper,wet and dry compression has been mathematically modelled by adding the molar fraction of steam to the CO_2-Argon mixture before and after the compression stage respectively. Wet compression refers to a direct steam feed through the compressor intake. Neither the effect of steam temperature nor the implementation method are addressed in this paper. CARSOXY driven cycles can increase the cycle efficiency in the right domains of operating conditions. Theses have been identified for each cycle. Efficiency increase can be up to 12% using heat exchanged cycle with dry compression. It has been the ultimate arrangement since it is more efficient than air driven cycle at any operation condition. The results have shown that the cycle efficacy using CARSOXY blends can be increased as the compressor inlet temperature decreases and the turbine inlet temperature increases. It can be concluded that a compressor inter-cooling system and a turbine re-heater can be used for CARSOXY driven cycles. Additional 10% increase of the cycle efficiency can be theoretically achieved by a new blend which has the molar fractions of 47% argon, 10% carbon dioxide, 10% H_2O and 33% oxy-fuels. Increasing Argon molar fraction and decreasing the molar fraction of H_2O have dominant effects on increasing the cycle efficiency.

SDEWES2018.0516

Effects of Air Pollution Control Devices on Fine Particulates Emission: Case Study of a 660 MW Coal-Fired Near-Zero Emission Unit in Beijing-Tianjin-Hebei Region

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Abstract

Due to the numerous coal-fired power plants in china, the near-zero emission reform of coal-fired power generation industry from 2014 has made a great contribution to emission reduction of China's power industry. In this research, we chose a 660 MW unit of a coal-fired near-zero emission power plant in Beijing-Tianjin-Hebei region. The particulate matters were sampled by DPLI (Dekati Low Pressure Impactor) at the inlet and outlet of air pollution control devices including SCR (selective catalytic reduction), LLTe (low-low temperature economizer), ESP (electrostatic precipitator), WFGD (limestone-gypsum wet flue gas desulfurization) and WESP (wet electrostatic precipitator). The removal efficiencies of PM_1, $PM_{2.5}$, PM_{10} and the concentrations of water-soluble ions in PM from different air pollution control devices were obtained after near-zero emission modification. The experimental results show that SCR can obviously increase the mass concentration of fine particles and increase the mass concentration of PM_1 by 52.11%. The concentrations of water-soluble Na^+, NH_4^+, Cl^- and SO_4^{2-} in PM_1 also increase. LLTe can improve the removal efficiency of ESP, especially for particles in the size range of 0.1-1 μm. The removal efficiency of water-soluble Na^+, NH_4^+, Mg^{2+}, Ca^{2+}, Cl^-, SO_4^{2-} and NO_3^- are all above 86% for ESP. The high-efficiency WFGD can remove SO_2 and fly ash simultaneously, but it will increase the mass concentration of PM_{1-} by 59.41%. The circulating slurry is richest in water-soluble Mg^{2+}, Cl^- and SO_4^{2-} which have the greatest increase in PM_{10} after WFGD. WESP has high removal efficiency for PM_1, $PM_{2.5}$, PM_{10} and can further reduce the dust concentration. Through near-zero emission reform, the final PM_{10} emission of the #4 unit is 2.04 mg/Nm^3.

Methods and technologies for sustainability

SDEWES2018.0041

Study on Flame Characteristics of Low Heat Value Gas in a Constant Volume Combustion Bomb

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Abstract

The flame combustion characteristics of low heat value (LHV) gas in a constant volume combustion bomb were studied. The flame radius, the stretched flame velocity, and laminar burning velocity at different ratio of N_2 and fuel/air equivalent ratio were obtained, while the turbulent flame propagation rate, Flame development time and rapid burning time of mean cycle, and flame surface wrinkle at different hydrogen fractions were also analysed. And the influence of different ignition positions on the flame surface wrinkle was studied. The experimental results show that the flame propagation speed is the fastest under the theoretical equivalent ratio. With the increase of volume fraction of N_2, the flame propagation speed decreases, the Flame development time of mean cycle increases rapidly, and the flame surface wrinkles gradually decreases. With the increase of hydrogen fraction, the turbulent flame rate and the flame surface wrinkle gradually increased, while the Flame development time of mean cycle shortened. The increase of N_2 and H_2 contents has little effect on the rapid burning time of mean cycle. The ignition position has a great influence on combustion efficiency and development form of the flame surface.

SDEWES2018.0257

Research of Hydrogen Consumption Detection Flowmeter Method for Fuel Cell Vehicles

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Abstract

In this paper, the original measurement accuracy of the Coriolis flowmeter is verified under nitrogen and hydrogen medium. The test results show that the measurement error under different medium is higher than the factory calibration value of the Coriolis flowmeter, which can't meet the requirements for hydrogen consumption of fuel cell vehicles. Therefore, it's necessary to study the factors that affect the measurement accuracy of Coriolis flowmeters.

Through the ANSYS-CFD simulation platform, the Coriolis flowmeter was modeled and simulated. The flow and velocity distributions of water and hydrogen at the same flow rate were studied, and the influence of the asymmetric distribution of the velocity field of the fluid on the phase detection of the Coriolis flowmeter under different medium was obtained, which was consistent with the test results of the flowmeter verification. Therefore, it can be concluded that when the actual measurement of the fluid medium is different from the calibration medium, the Coriolis flowmeter measurement error will be caused.

In order to reduce the error of the Coriolis flowmeter in the hydrogen consumption detection of the fuel cell vehicle, this paper uses the sonic nozzle calibration device to calibrate the actual flow rate of the Coriolis flowmeter. And the Coriolis flowmeter was tested under steady and dynamic conditions in hydrogen medium. The test results show that the measurement accuracy of the calibrated Coriolis flowmeter is less than 1%, to meet the requirements of fuel cell vehicle hydrogen consumption testing, and to provide a theoretical basis for the application of flowmeter method in fuel cell vehicle economic evaluation methods.

SDEWES2018.0437

Challenge for Coordination Consumption of a Pool of Prosumer

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Abstract

The residential-scale solar photovoltaic (PV) system prices is dropping in last ten years, a simple household could become an active energy consumers, often called 'prosumers' because they both consume and produce electricity. In one hand, they could dramatically change the electricity system. In other hand, household without PV system could reduce their cost by buying electricity from other prosumer. In order to create this eco-system, the coordination mechanism among prosumer is necessary. This paper focus on a sharing economical model based on the simulation of load shifting. A simple mechanism for shifting two shiftable appliances that applied to a community of ten households in a full year simulation, where consumer did not buy energy from grid when the excess energy from prosumers are still available. Consumer also reduce their cost for electricity from grid when they participate in this program. Prosumer also get benefit from this coordination, in one hand their consumption meet with the electricity and store energy for off peak period. In another hand, they also receive income from consumer and grid.

SDEWES2018.0500

Numerical and Experimental Study of an Air Extraction System

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Abstract

Air extraction hoods for kitchens are, despite their apparent conceptual simplicity, complex thermo-fluid systems, whose design is still being carried out mostly empirically. As the attention paid to energy savings is rising, the competitiveness of a product is more and more related to its energy performance. This field of industry makes no exception, and is showing increasing interest towards state-of-the-art design tools like Computational Fluid Dynamics (CFD) and optimization processes.

The case of interest of this study is an extraction system for a relatively large kitchen. It is to be mentioned that large scale kitchen hoods are usually provided with an air reintroduction system in order to keep the kitchen pressure from getting significantly lower than the environment. In order not to alter the room temperature, thus keeping a satisfactory level of comfort for the operators, the incoming flow of external air has to be heated or cooled most days of the year, leading to a significant energetic cost. This led the main companies in this field to design systems which re-introduce part of the air directly under the hood: as this air is extracted before it can reach the kitchen environment there is no need to treat it thermally. Such an approach, while leading to a notable energetic saving, concedes a decrease of the suction efficiency, since the extraction is partially busy moving clean air from the outside. At the same time, the presence of a jet, below the hood ceiling, directed towards the extraction filters may have a beneficial effect dragging in the warmer air and steam coming from the cooking processes. Adding to the complexity, the air to be extracted is mostly buoyancy-driven as it starts its path upwards at the cooker level, and enters then a forced convection area with relatively high speed flows.

In the present work, the behavior of the system is investigated by means of Finite-Volume based Reynolds Averaged Navier Stokes 2D simulations of a central section of the hood. A reliable model is obtained and validated against the results of an in situ measurement campaign, carried out on an existing installation. The obtained model can then be used to perform a parametric study, in order to determine the influence of a number of parameters (such as inlet angle and flow rate) on the system effectiveness.

SDEWES2018.0546

Energy Transition in Existing Districts in the Hague, a Bottom Up Approach

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Abstract

The 2015 Paris agreements [1], the depletion of fossil fuels, and the variety of damages caused by the production and consumption of fossil fuels necessitate a transition in energy systems. The Netherlands prioritised a transition in residential heating. This transition will not occur by itself, i.e. by a superior technology replacing an outdated predecessor; it takes policy measures to successfully introduce renewable technologies. Moreover, technological, political and economic issues intermingle. Citizens organise themselves in order to influence/define their heating system. This paper will analyse a project in action that aims at facilitating citizens in the city of The Hague to play a role in this transition process.

Energy producers, energy network companies, housing corporations, resident associations and the municipality of The Hague have reached an agreement on renewable energy. Their aim for the coming 5 years is to upgrade 30.000 dwellings in 10 districts to the level of climate neutrality. Besides the Paris agreement, The Hague follows the announced governmental policies to terminate exploitation of natural gas reserves and to stop the use of natural gas in dwellings.

In The Hague and other cities there are many examples of bottom up energy cooperatives that have successfully initiated concrete steps in this energy transition. On the other hand, the organizational abilities of different groups are not equal and we must acknowledge the fact that in any major transition there are winners and losers [2]. For this reason, a lot of attention has to be given to a comprehensive guidance of the transition process.

The objective of this paper is to analyse our attempts to find a suitable method for supporting the energy transition process in existing districts in major cities, with participation of all major stakeholders. The interests of the residents are most important in this perspective. The research question is:

"Under what conditions can resident groups create a widely supported plan that is in line with the local/regional energy transition policy."

This paper will report on the work in progress. The actual challenge of replacing natural gas is undisputed. District wide support for a strategy is conditional for any successful transition. This research will seek the conditions that have to be met

SDEWES2018.0598

Winery Water Footprint Assessment: a Portuguese Reality

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Abstract

In Mediterranean region, climate change has already prompted concern in the wine sector, due to the strong impact that extreme climatic events have on the vineyard productivity and wine quality. The adoption of the best available techniques, aiming at sustainable production, and therefore reducing the impact on natural resources is a goal of wine industry. The reduction of wineries water consumption can contribute to reduce both natural resources dependence and production costs. In Portugal there are no information regarding water footprint at Level C – case study, for Alentejo and Tejo regions. The objective of this work was to determine the water footprint of two medium sized wineries located at two of the most important Portuguese wine regions, through direct measurements. At the winery, it was determined blue and grey water footprint components at each step of the production process through the monitoring of water consumption, wastewater characterization, wastewater treatment efficiency, observation (gemba walks) and a questionnaire. The functional unit selected for the study was 0.75 L, of a wine bottle, and the monitoring was performed during one year. The results obtained showed a winery water footprint value of about 6.0 and 1.9 L of water per wine bottle, regarding Alentejo and Tejo case study respectively. The differences observed between the two case studies are related to the existent wastewater treatment process. It is therefore essential to fully characterise wineries water consumption/pollution pattern in order to identify hotspots than may allow the reduction of the winery water footprint along the production process. This study, based on two case studies with all the data collected in site, is an important improvement for the existent knowledge about water use in Portuguese wineries.

Society and economy

SDEWES2018.0059

Socio-Economic Analysis of Community Gardens: (Un)Intended Way to Adapt the City to Climate Change

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Abstract

Over the last decades, there has been a rapid population growth, but above all, the rate of urbanization has been rising as well. Adaptation strategies (e.g., EU Adaptation Strategy) are being developed and appropriate measures are implemented in the context of climate change. At the same time there are changes in society that are accompanied by changes in lifestyle. Part of the citizens lacks the opportunity to cultivate their own crops. This issue is partly solved by community gardens. Besides their primary function (crop growing) community gardens have a number of co-benefits for its members (such as meeting people and active leisure activities) and also for the whole society. According to their specific form and location, community gardens provide a wide range of ecosystem services.

The goal of this paper is to identify, qualify and quantify both private and social benefits and use the results to increase the society's awareness about community gardens' benefits. Another goal is to analyze the motivation behind becoming a community garden member. The paper presents the results of economic and social analysis. The economic evaluation was carried out using modified cost-benefit analysis, the social analysis using a questionnaire survey among members. The pilot evaluation was carried out on two gardens in the Czech Republic with different cultivation method (CG Kuchynka and CG Vidimova).

For both gardens, the motivation was rather similar. The quality of the grown crops plays a major role. One of the crucial aspects for CG Kuchynka members is food self-sufficiency, which significantly influences the motivation of its members. Both gardens can be considered as effective adaptation measures, because net social benefits were demonstrated through the CBA. Benefits used for the evaluation include in particular grown crops, rainwater retention, improving water quality, air quality, carbon storage and increase in aesthetic value. Educational function was taken into account in the case of CG Vidimova. The remaining benefits were not monetized. The net present benefits were estimated at EUR 1,300 for CG Vidimova and EUR 34,000 for CG Kuchynka in a 50-year horizon. The benefits are considered to be underestimated because recreational benefits were not included in the analysis. Although both gardens can be presented as beneficial not only to their members, but also to the neighborhood, only a small number of their members are fully aware of this.

SDEWES2018.0149

Business and Socioeconomic Assessment of Introducing Heat Pumps with Heat Storage in Small-Scale District Heating Systems

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Abstract

Fossil fuel-based cogeneration of heat and power (CHP) plants has had a long-standing track-record in providing space heating and domestic hot water through district heating systems in Denmark. Small-scale district heating systems are progressively switching to biomass boiler-based due to decreasing spot market electricity costs, increasing fuel costs and worsening framework conditions for CHP plants. At the same time, however, biomass resources should be reserved for other purposes and analyses indicate that small-scale district heating systems should switch to heat pump-based heat production. In this paper, we investigate the transition of district heating systems on the Danish renewable energy island Samsø. While the heating system is already renewable energy-based through the use of a biomass boiler, the system is neither economically optimal nor optimal in terms of integrating fluctuating renewable energy sources. The analyses are conducted in two steps. In the first step through EnergyPLAN-based overall energy systems analyses of Samsø with heat pumps replacing district heating biomass boilers and investigating system impacts, the ability to integrate fluctuating renewables and overall systems costs. In the second step through analyses of optimal business economic design and operation of the district heating plant through analyses using the energyPRO model where plant operation is optimised against an external electricity market. Results show that while from a general systems perspective, heat pumps give a positive impact when factoring in the ability to exploit locally available fluctuating renewable energy sources and local biomass availability constraints, business economic analyses demonstrate a more uncertain feasibility of the potential switch and also demonstrate that added flexibility through extensive heat storage and overcapacity on heat pumps does not pay.

SDEWES2018.0193

Stakeholder Engagement Towards Harmonization of Sustainable Urban Energy and Mobility Planning

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Abstract

In the last decades, participation processes have been widely used for the development of sustainable strategies. The results coming from the use of this technique, considered valuable resource to obtain transparent and accepted strategies, are not always successful due to limitations and challenges that already exist in their design and application. The development of an environmental strategy by adopting participation techniques is the core of the SIMPLA H2020 project that aims to create a strategy for the harmonisation of energy and mobility plans with the support of different kinds of actors at national and local levels. In this context a specific method was developed for the SIMPLA's stakeholder engagement following a vertical approach and three steps. Each step aims to involve a different actor's typology group from the upper (national) to the lower level (local). In order to achieve an effective engagement, the method defines which participation technique is the most appropriate for each level and how the outputs of participation sessions should be collected to facilitate the exchange of information among the stakeholders at different levels. This paper presents the method describing the stakeholders' groups identified at each level and why the selected participation techniques and formats of the outputs have been considered as the most appropriate. After presenting the method, the paper shows how it was implemented in Spanish territories within the framework of SIMPLA in order to enhance and validate the "SIMPLA guidelines for the harmonization of energy and mobility planning". Thus, both the outcomes of each participation session carried out (one focus group and two workshops) and a resume of the main contributions that has been included in the first version of the guidelines are presented. Finally, to facilitate the replication and the improvement of the method in other contexts, the conclusions summarise the main approaches that should be adopted when designing a vertical participation process to address the gaps that nowadays impede the achievement of successful stakeholder engagement campaigns.

SDEWES2018.0463

Covenant of Mayors Signatories Leading the Way Towards a 1.5 Degree Future

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Abstract

Despite the increasing number of cities and local governments adhering to transnational initiatives active in climate change action, we are currently lacking a systematic knowledge on their contribution to the Paris Agreement. In view to close this research gap, the article focuses on the climate mitigation trajectory to 2050 of Covenant of Mayors (CoM) signatories. The CoM initiative registered as of October 2017 more than 7600 signatories covering 238 million inhabitants mainly from European cities. Out of these, 533 signatories have reported on the implementation of their climate action plans and 207 signatories have declared a long term target beyond 2020. In this paper we examine the aggregated effort of the CoM signatories in terms of geographical distribution, mitigation ambition and achievements, and also discuss whether the projected emissions reductions are in line with a 2°C and 1.5°C pathways. Given the currently limited number of signatories presenting long-term visions and achievements, extrapolation has been applied to get an estimate of the CoM signatories' trajectory to 2050. For this reason, the whole CoM dataset has been divided in clusters, on the basis of three factors: the climatic features, degree of urbanization and the level of target ambition in pursuing CO_2 emissions reductions. Results confirm the strong potential of the CoM initiative in contributing to ambitious mid-century mitigation targets

SDEWES2018.0475

Social - Cost Benefit Analysis of Sewage Waste Water Treatment Plants in Delhi

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Abstract

Clean water is not only essential for life but beholds socio – economic aspect of living. India being the fastest growing counties in the world also faces the challenge of availability of usable water. Delhi, the national capital, has been consistently facing crises of usable and safe drinking water. Population growth, growth of slums, migration resulted in inadequate water supply and sanitation services. Further, deficient rainfall and extremely warm climate also created water shortage in the capital. Moreover, there is an extreme requirement efficient infrastructure with minimum leakage. Since the water holds a socio-economic impact on the society, it is more essential to conduct a social- cost benefit analysis to evaluate the performance of these plants. In this context the present study selects two plants namely, Kondli Sewage Treatment plant and Okhla Sewage treatment plant to evaluate them on the basis of cost – benefit approach.

The main objective of the study is to analyze Socio – Economic impact of the two Sewage Plants in Delhi using Cost- Benefit Analysis in order to compare the costs and benefits of two plants. The aim is to comprehend the economic, health, environmental and ecological impact of these sewage water treatment plants. On the basis of data collected, an assessment related to the benefits like social, economic, environmental, economic and ecological have been made in the study.

The study reveals that in case of both the plants total cost comprises of fixed cost, cost of electricity consumption, maintenance cost, cost involved in dumping of manure. The benefits consist of social, economic, ecological and environmental benefits. The social benefits comprise of the employment generated from the project, the health related benefits provided to the employees every six months and also the supply of water for horticulture, Delhi Transport Corporation (DTC) depot, Public Works Department (PWD) for gardening and groundwater recharge.The results clearly reveal that employment generated by Okhla plant is much higher than the Kondli plant. The fixed cost of Okhla plant is higher than Kondli while total area covered by Kondli is much higher than Okhla. The construction cost involved in Kondli sewage plant is much higher than Okhla sewage plant.

The study reflects several policy implications. The land covered under each sewage plant is a green belt and also a habitat of variety of wildlife and ecosystem which could be developed as national park for the community with a minimal entry charge and earn revenue. Further the process of waste water treatment has a huge potential of generating electricity from biogas (sludge) but its potential is still unutilized. A huge potential of stand – alone solar plant will not only generate electricity for running the waste water sewage plant but can also feed the excess electricity generated to the main grid.

SDEWES2018.0584

On the Challenges of Empowering Citizens in Technological Innovation Matters

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Abstract

In order to counteract a constant global warming, the inclusion and empowerment of civil society and economy are considered necessary prerequisites for the energy transition that is to be achieved. Responsive and deliberative forms of participation have to be considered in an early phase of a project and employed continuously throughout the intention.

However, there are common challenges within participation processes. We illustrate a use case consisting in the implementation of technological innovations using a slow bottom-up approach. Our main thesis suggests that an active interference of social space leads to higher technology acceptance and therefore to an easier implementation of innovative technologies to increase the citizen's life quality. Due to the fact that our target group shows high diversity we focus on specific mediators that influence technology acceptance. Therefore we conducted a mixed-method approach with quantitative and qualitative components.

We present the main results and experiences of the first project phase. The quantitative research presents connections between mediators like age, health status, social environment. To understand the target group's attitudes to a greater extent, qualitative deepness is required to close the gap between individual and general needs. Also, the results show tendencies that social activities can be used to promote environmental awareness raising. But flexibility is needed to reach the individual needs and to motivate the target groups to participate. This may include different options of innovative technologies or offering various tools at the participation process.

Renewable energy sources

SDEWES2018.0271

Determining the Thermal Efficiency of a Polymer Solar Collector Using Numerical Methods

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Abstract

With the use of polymeric materials, such as polycarbonate or poly (methyl methacrylate), it is possible to relatively easily alter the design of the flat plate collector to achieve as high as possible values of thermal efficiency and to produce technically competitive collectors at lower costs than the state-of-the-art flat plate ones. Determination of the thermal efficiency is one of the crucial parts of the process of the design optimization. To assess the thermal efficiency of various designs of the polymer solar collector, different 2D numerical models were used. Because the design of the polymer solar collector is often more complex compared to the standard flat plate collector, the more complex numerical models may be considered, such as discrete ordinate (DO) radiation model. The developed models were first analytically and experimentally evaluated against the standard flat plate collector. Furthermore, the separate numerical models are applied to a computational domain of simplified geometry. The solar incident radiation is modeled with the ray tracing software. These models are then validated experimentally to confirm the accuracy of the ray tracing software. The most appropriate model is selected to obtain the efficiency of a polymer solar collector prototype. The results show that polymer solar collector has 3.45% lower efficiency when the temperature difference between water and ambient temperate is zero. As the water temperature increases, the efficiency curve of a polymer collector has steeper characteristic than the flat plate one due to inferior thermal properties of a polycarbonate. Moreover, the developed model can be applied to various designs of solar collectors made of different materials to evaluate the thermal performances.

SDEWES2018.0446

A New Analytical Model for Pile Ground Heat Exchangers Considering Temperature Variation on Ground Surface

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Abstract

Ground coupled heat pump (GCHP) systems have been recognized as an effective sustainable energy technology for air conditioning in buildings. Thermal analysis of ground heat exchangers (GHE) is critical to system design and operation. The ground surface condition can significantly affect the thermal performance of GHE, especially pile GHE (PGHE) which is much shorter in depth compared with borehole GHE (BGHE). However, in modelling the temperature response of PGHE, the ground surface temperature is usually assumed to be remaining the same as the initial temperature. The study of the effect of the ground surface on the thermal performance of PGHE is limited. Therefore, this paper presented a new analytical model for PGHE based on Laplace transform method and Hankel transform method, where the excess temperature of the ground surface is taken into account. The two transform methods are integral-transform methods, which are different from the Green's function method in solving heat transfer problems. The new analytical model considers the PGHE as a solid cylindrical heat source. The model is validated by comparing the solution of the model with that of the existing Green's function based analytical model for PGHE, both under the condition of no temperature rise on the ground surface. The results show that the excess temperature of ground surface may have significant effects on the thermal performance of PGHE. The shorter the depth of PGHE and the bigger the excess of ground surface temperature, the more important the ground surface condition be considered in the thermal analysis of GHE.

SDEWES2018.0554

A New Software for the Techno-Economic Analysis of Small Hydro Power Plants

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Abstract

Project SMART (Strategies to Promote Small Scale Hydro Electricity Production in Europe) from the Intelligent Energy Europe (IEE) program, in which 7 institutions from 5 European states participate (Province of Cremona – Italy; CESI RICERCA SPA – Italy; Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb – Croatia; Karlovac Regional Authority – Croatia; Norwegian University of Science and Technology – Norway; Regional Secretariat of Attica - Greece and Energieagentur Waldviertel – Austria), address to important barriers for the expansion of small-scale hydro electricity (SHP) production in Europe: the lack of suitable support methodologies and tools; the complexity of the legal/administrative processes to obtain concessions, and the economical/financial attraction of private investors.One of the main barriers is the lack of suitable methodology and tools (computer programs) able to create a clear view of the smal hydro power potential in the given territory, as well as a complete techno-economic analysis for certain location. Although, in the world there are a certain number of computer programs for this purpose, but they are not able to take into account all the specifics of watercourses. Due to, a new original numerical tool (software) for the techno-economic analysis of small hydropower plants is developed and will be presented in this paper. In the software the latest knowledges and technical developments in the field of small hydropower plants are incorporated (e.g. the newest types of water turbines for small hydropower plants). Also, the interface of the software is also designed to allow appropriate application. The program is very useful for experts in the field of small hydropower plants, but also much wider, for decision-makers, potential investors and stakeholders. It will improve water resources management, disseminate opportunities to investors and increase the interest of stakeholders to invest in SHP, resulting in their wider use.

SDEWES2018.0562

Environmental and Economic Life Cycle Assessment of a BIPV System Installed in an University Campus in Mendoza (Argentina)

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Abstract

Distributed PV generation can help tackling many environmental concerns of society: the depletion of non-renewable energy sources, climate change, urban pollution, etc.

However, the economic and environmental benefits of these technologies are dependent on many variables, and it is not always certain whether the system will produce positive results. In this study a Building Integrated Photovoltaic (BIPV) system installed in a university campus in Mendoza is presented and evaluated from these points of view.

The system is made up of 12 PV panels which have been installed as overhangs, thus blocking the solar radiation before entering the classrooms during the hot periods of the year, and transforming it into electricity.

The economic assessment of the BIPV system is performed using Life Cycle Costing (LCC), considering initial investment and future replacement and maintenance costs, as well as the economic benefits of electricity generation. The economic aspect of the shading effect of the system has been assessed considering the avoided costs of acquisition, installation, replacement and maintenance of an alternative sunshade. In order to properly handle sensitive variables such as discount rate, energy costs and projections of future electricity increase rates different scenarios have been considered.

Life Cycle Assessment was used for the evaluation of the environmental aspects of the system. The double function of the BIPV system has been handled following the boundaries expansion approach. The impact assessment stage was performed using indicators for cumulative energy demand and Global warming potential.

Results show that current economic conditions are not attractive for the implementation of PV systems in the residential sector of the country, despite the sharp decrease of PV panel costs. The payback period is beyond the expected useful life of the PV system, even when a zero discount rate is considered. However, the strategy of integration of the PV system as an overhang is enough to overcome the economic deficit of the system.

From the environmental point of view the results are very encouraging in every impact category compared with the displaced electricity. GWP is 97.3 gCO2eq/kWh which is about one fifth of the Argentinean average emission factor. The energy payback period (EPBP) is reached in 9 years. When the double function is taken into account, GWP is only 55 gCO2eq/kWh, while EPBP is reached in only 5.2 years.

SDEWES2018.0571

The Role of Second-Life Batteries on Renewable Based Power Systems

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Abstract

Electric mobility is taking of, and it will represent a large share of the global automobile market in the next decades. The batteries of these vehicles are typically replaced while still having a significant remaining capacity, thus they are suitable for alternative uses, creating in the medium-long term opportunities for their repurpose to domestic applications or to direct coupling to renewable energy systems. This study analyses from a technical and energy balances viewpoint how a large power system can take advantage of second-life batteries to store potential excess of non-controllable renewable energy.

For that, it uses the future Portuguese power system as case study. It couples a model of electric mobility diffusion and second-life batteries availability with various EnergyPlan simulation models of the power system for the period 2030-2050, comprising sub-models of unidirectional smart charging of electric vehicles. The results are illustrated and quantified against a base case scenario, which disregard second-life battery storage. Load diagrams of the power system are shown, and it is quantified to what extent this solution may facilitate the deployment of solar-photovoltaics and reduce the needs for imports and exports and abroad interconnection capacity. Since the Portuguese power system is largely based on hydro energy, the results are shown both for the cases of a normal and a dry year.

The results show that by 2050 the second-life batteries market should represent about 38 GWh of storage capacity. On a normal year, they allow to reduce the amount of energy in excess from 0.77 to 0.03 TWh, and mostly they are operated during the summer at an average charging and discharging rates of 251 and 181 MW, respectively. In terms of renewables integration, the batteries should allow an additional 3,581 MW of photovoltaics deployment, which allow to increase the electricity renewable share by 4%. Concerning environmental benefits, the batteries allow to decrease CO_2 emissions by 0.2 Mton, which represent 3,4% of total emissions from the power system. If one considers the scenario with increased photovoltaics deployment that they allow, the reduction of CO_2 emissions ascends to 32%. For the dry year scenario, the results are that the repurposed batteries are capable to fully compensate the lower storage capacity in the dams, supplying the grid when requested. In spite of these results, it was found that the capacity factor of the second-life batteries should be low (about 5%), since the Portuguese power system already comprises a large hydro-pumping capacity to store energy, suggesting that in systems where this is not the case the batteries should become more relevant.

SDEWES2018.0611

Preparation and Characterization of Heat Transfer Fluid Including Solar-Thermal and Latent Heat Storage Materials for Application in Direct Absorption Solar Collectors

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Abstract

During the past decays, solar energy utilization offers a promising sustainable solution to the energy crisis due to its free availability and least environmental affect. The potential of solar-thermal radiation is bigger than all other forms of renewable energy combined. Solar thermal collectors are the essential components of each solar thermal systems. To simplify the typical solar thermal collector, enhance the efficiency and overcome the corrosion and heating losses in existence types, a so-called Direct Absorption Solar Collector (DASC) has been proposed. In a DASC, solar energy is directly absorbed and then transferred by the working fluid. Besides low efficiencies of currently available solar collectors, the widespread adoption in general, and of DASC in particular, is limited by the time mismatch between the availability of solar energy and the demand. Therefore, an interesting concept to overcome the above-mentioned limitations is to add latent heat thermal storage materials to the heat carrier which can be exploited in combination with the sensible heat of the carrier itself. This technology of DASC is in the research phase but the previous experimental and numerical studies confirmed that can be applied in broad application prospects in the building heating/cooling systems.

In this study a slurry containing encapsulated palmitic acid within silica supporting material, as the latent heat term together with carbon black nanoparticles as the photothermal term is introduced. The chemical structure, surface morphology, morphological structure, and thermal properties were studied by using FTIR, SEM, TEM and DSC, respectively. SEM photos indicated that the encapsulated PCMs were prepared spherically within silica in homogenous particle sizes with a smooth surface. All characteristic peaks of palmitic acid and silica were observed in the FTIR spectra. The DSC results indicated the latent heat of 74.8 and 68.5 J/g for the melting and solidifying process of encapsualetd PCMs, respectively. The results confirmed that the prepared PA/SiO_2 encapsulated particles are appropriate PCMs for utilizing in slurry thermal energy storage applications. Furthermore, a photothermal nanofluid including carbon black nanoparticles were prepared. The stability, surface charge and rheological properties of the prepared nanofluid were determined by using UV-VIS spectrometer, zeta potential and viscometer, respectively. The prepared nanofluid and encapsulated PCM were utilized in the following process to develop a stable solar thermal water-based heat transfer fluid (HTF) for application in DASC. Graphite nanopowder is used as the photo-thermal particle along with the PA/SiO_2 as the heat storage segment. The obtained slurries can act both as a heat transfer fluid and thermal energy storage medium, making the system more energy-efficient and compact.

Waste and wastewater treatment and reuse 2

SDEWES2018.0056

Analyzing the Decision to Invest in Recycling: the Role of Demand Uncertainty and the Rebound Effect

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Abstract

The reduction in virgin material consumption is considered as one of the most important environmental benefits of the transition towards a circular economy. However, as positive externalities are not internalized and investors face demand uncertainty, private investments in the circular economy are lagging behind.

Objective: This study analyzes a monopolistic firm with the option to invest in a recycling facility, taking into account demand uncertainty. We evaluate two scenarios: in scenario 1 the firm makes an investment analysis taking into account demand uncertainty. In scenario 2 the firm makes an investment analysis taking into account demand uncertainty, but also accounts for potential rebound effects. Such rebound effects occur whenever recycled material does not fully displaces the virgin material. The objective is to analyze the environmental impact of displacing virgin material on the decision to invest in a recycling facility, taken into account demand uncertainty. We apply the theoretical framework to a case study in the plastics waste industry.

Method: We extend an existing real options model and incorporate the environmental externalities of recycling. Using this extended model we compute the optimal investment thresholds i.e. the optimal time of investment and the optimal investment capacity. To the best of our knowledge, we are the first to use a real options model to study investment decisions under demand uncertainty within the circular economy while taking into account environmental externalities.

Results: We find that demand uncertainty postpones investment and increases the optimal capacity level. As long as the rebound effect is limited and thus the net environmental externality is positive, the optimal time of investment is advanced.

We conclude that investment thresholds depend on demand uncertainty and the internalization of the environmental externalities of recycling. The internalization of these externalities reduces the impact of demand uncertainty, leads to early adoption of recycling facilities and increased social welfare.

SDEWES2018.0085

Combined Membrane and Thermal Desalination Processes for the Treatment of Ion Exchange Resins Spent Brine

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Abstract

The disposal of polluted brines coming from industrial processes constitutes a very critical environmental issue. It follows the necessity of developing new solutions to treat the brines, removing the pollutants and recovering the re-usable materials.

This work is focused on the development, modelling and techno-economic assessment of a suitable treatment chain for the effluent produced by the regeneration process of Ion Exchange resins employed in a demineralization plant for water softening. The regeneration is performed via a NaCl-water solution and the effluent presents NaCl and bivalent cations, namely Mg^{++} and Ca^{++}, while the amount of organic pollutants results negligible. The treatment chain provides the separation of the bivalent cations via a nanofiltration stage, combined with a membrane crystallizer, to produce $Mg(OH)_2$ and $Ca(OH)_2$. Conversely, the remaining NaCl-water solution is sent to a Multi-Effect Distillation unit, where it is concentrated up to the concentration required to the regenerant solution for the next IEX regeneration cycle. Three techno-economic models were implemented in Python for each of the mentioned processes. These models were interconnected in an integrated simulation environment, the Remote Component Environment (RCE) software, to simulate the whole chain.

The valuable product is the concentrated brine produced by the MED, whose levelized cost constitutes the main performance indicator (Levelized Brine Cost, LBC). This cost was compared with the current cost of the fresh regenerant solution, around 8 US$/m^3. The overall performances were evaluated varying several parameters, including the NF membrane properties, the availability and quality of waste heat in the industrial site, the energy costs and the selling price of water, $Mg(OH)_2$ and $Ca(OH)_2$. The MED process has the highest contributions to the total capital and operating costs, but it renders itself as a promising option in situations where low cost waste heat is available at the industrial site. Furthermore, we found that the revenues resulting from $Mg(OH)_2$ and water production have the most prominent role in the definition of the LBC.

In conclusion, this system results competitive for a wide range of operating conditions and it constitutes a step forward in the application of circular economy at the industrial scale.

SDEWES2018.0100

Management of Household Food Waste from Residential Areas

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Abstract

The minimization of landfill deposition of waste containing biological components represents a big problem, especially in built-up residential areas. The main problem of biologically degradable municipal waste is the quantity and composition of household waste which can have an important influence on decomposition processes already in collecting vessels. An amount of household waste produced in residential areas in the Czech Republic varies from 31 to 337 g/person/day, with an average value of 250 g. Waste of plant material character is produced in the range from 22 to 291 g/person/day. Composts were prepared in the home composters from household food waste. After end of the composting process, compost have not the organic component sufficiently stabilized, which is documented by high value of electrical conductivity of aqueous leachate reaching more than 4 mS/cm and low humification coefficient. The value of the humification coefficient pronouncedly increased after eight weeks from 0.05 to 0.85, while compost from composting of green waste using windrow system have humification coefficient of 3.48.

SDEWES2018.0238

Energy Embedded in the Management of Food Waste and in the Production of Uneaten Food: Seeking for a Sustainable Pathway

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Abstract

While the relationship between energy and food is widely known from the perspective of nutritional energy supply, little is known about the energy embedded in its production. On average, 10 kcal of fossil fuel are needed to supply one kcal of food to consumer. This has been estimated to involve around 30% of final energy demand, with more than 70 % consumed beyond the farm gate (FAO 2011). However, estimations are often limited from farm to plate, disregarding the resources spent in managing food waste after it has been disposed. In this sense, more than a third of food produced is lost along the chain, involving around 38% of the energy consumed in its production (OECD, 2017). Food is lost at every stage of the supply chain, with its embodied energy amount building up along the chain.

This work aims at the estimation of the energy resources embedded in the management of food waste and in the production of uneaten food of the Spanish agri-food system. For this purpose, an energy flow analysis is performed beyond the plate. Agricultural production, processing and packaging, wholesale and retail, consumption and waste management are included within the system boundaries. Various food waste management options are considered, distinguishing among landfilling, composting, anaerobic digestion, and incineration. Food commodities are grouped into cereals, sugar, vegetable oils, vegetables, fruits, pulses, roots & tubers, dairy, eggs, fish & seafood, meat & animal fat. The methodological approach introduces an energetic footprint indicator (EFI), which relies on linear programing to assess the energy intensity of the different management alternatives and stablishes the most sustainable pathway for each food commodity at each supply stage.

SDEWES2018.0347

Applications of Corona-Discharged Plasma and Manganese Catalyst for the Removal of Acetaldehyde

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Abstract

Emission of volatile organic compounds (VOCs) is one of the serious environmental issues since these compounds are generally classified as either hazardous air pollutants or photochemical ozone precursors. Regulations on VOC emission from industrial sources have been intensified to minimize the air pollution problems in many countries. Nevertheless, VOC emission from various small-scale, domestic sources including barbequing restaurants and automobile repair shops is not easy to control. In this study, a combined system consisting of non-thermal corona-discharge plasma and manganese catalyst was developed to provide a control option to those small-scale sources. The corona-discharge plasma was operated at an electrical input of 10 kV and 1.0 mA, and the manganese catalyst prepared using a wet deposition method on the surface of cordierite was utilized. VOC removal efficiencies were tested using acetaldehyde as a model compound at room temperature. In a closed, batch experiment, acetaldehyde at a vapor-phase concentration of 6 ppm was completely oxidized within an hour. Meanwhile, the concentration of ozone increased as inversely proportional to the rate of acetaldehyde degradation. In addition, a 10-day continuous operation was conducted to evaluate catalyst performance, and the manganese catalyst maintained its VOC-degrading activity during the long-term experiment. However, XRD data for virgin and used catalysts showed that manganese oxide peaks decreased after exposed to acetaldehyde and ozone, indicating that possible catalyst poisoning took place. To ensure system feasibility for a real-scale application, catalyst stability and lifetime need to be further evaluated.

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Leaching of Nickel and Vanadium from the Spent Fluid Catalytic Cracking Catalyst by Reconnoitering the Potential of Aspergillus Niger

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Abstract

Present study evaluates the biopotential of Aspergillus niger to leach out Nickel, Vanadium from spent fluid catalytic cracking catalyst (SFCCC) and is compared with chemical leaching efficiency of various organic and inorganic acids. Extensively used chemical leaching is no more an obvious solution to recover metals due to high energy requirements and potential for environmental damage. Bioleaching being greener process is exploited to extract Nickel and Vanadium through one-step bioleaching (OSB) and spent medium bioleaching. The final biomass achieved was between 11 to16 g/l for 1 to 5% (w/v) pulp densities. The lowest pH recorded was 3.22, suggesting acidolysis as the principal leaching mechanism. Bioleaching efficiency of Nickel at 1, 3 and 5% pulp densities were 16.5, 13 and 8% respectively. The percentage Vanadium leaching at same pulp densities was found to be 55, 37 and 27% respectively. Leaching efficiency decreased with increase in pulp density due to the toxic effect caused by metals of SFCCC on Aspergillus niger. Complete inhibition of Aspergillus niger growth was observed at 7% pulp density. The spent medium bioleaching resulted in 4.7% Nickel and 18% Vanadium leaching, which is way less than leaching efficiency offered in OSB. This is attributed to high Citric acid production (100mM) in OSB which was triggered by few metals of SFCCC. Oxalic acid was found to be the dominant leaching agent for Nickel compared to other organic and inorganic acid including OSB and spent medium bioleaching. While with Vanadium, OSB took over. The unwrapped truth was leaching of Nickel was only due to predominant acids produced by Aspergillus niger. On the other side, “Biogenically produced leaching agents” apart from predominant acids solely accounted for 40% of Vanadium leaching. Also, it is evident that removal of volatile carbonaceous material from SFCCC improved Nickel leaching by three folds.

Energy storage

SDEWES2018.0080

Techno-Economic Assessment of Seasonal Heat Storage in District Heating with Thermochemical Materials

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Abstract

Sensitive storage systems as currently in focus of demonstration projects in common district heating (DH) grids for the seasonal storage of excess heat show high space requirements, investment costs and heat losses. As an alternative, the usage of thermochemical storage (TCS) materials seems reasonable in certain scopes. By the use of reversible chemical reactions and isolated storage of the reactants, seasonal storage at ambient temperature is rendered possible. As these technologies are still on a low TRL and not yet available for large-scale applications a detailed comparison with state of the art technologies is difficult. Therefore, a techno-economic assessment of potential TCS materials, including necessary conversion reactors, energy and transport costs, allows a general evaluation of the competitiveness of the technology.

The paper targets the economic considerations in the comparison of the specific costs for different storage technologies and their integration into DH grids, examining feasible TCS materials, together with potential stocking and conversion paths. Potential storage materials were selected by evaluation of different factors, like price & availability, energy density and hazard classes. Heat generation costs per storage cycle (full charge & discharge, stocking, transport) were elaborated and compared, using established technologies as a benchmark.

The analysis was done for different DH grid sizes: (1) large urban grid, (2) small urban grid, (3) rural grid. To show the influence of individual cost factors (grid size, energy source, etc.), a set of scenarios was defined. Calculations were done for a seasonal storage assuming an operational lifetime of 20 years.

The analysis reveal expectable generation costs for seasonal heat storage using TCS materials in combination with renewable energy sources. Hence, it allows an early estimation of the competitiveness of future heat storages with yet commonly used technologies.

Thermochemical heat storages are not yet available for large-scale applications in DH grids. Thus, this paper provides an overview of materials conceivable in the medium-term for different grid sizes and load profiles (base-/peak-load) and identifies approximated cost structures for these applications. Additionally, economic and ecological risks and limitations concerning preparation and processing of the investigated materials are pointed out to fully consider environmental influences over their potential advantages on costs.

SDEWES2018.0108

Transient Thermal Analysis of Phase Change Material Based Buffering Technology in Waste-to-Energy Plant for System Efficiency Enhancement

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Abstract

Energy efficiency of current Waste-to-Energy (WtE) plants is mainly limited by high temperature corrosion combined with temperature fluctuation of flue gas, which is caused by inhomogeneous composition of solid waste. This paper aims to examine the introduction of a technology based on Phase Change Materials (PCMs) in the combustion chamber and the impact on the energy efficiency of waterwall. This technology encapsulates PCMs based on aluminium alloys in ceramic bricks similar to traditional refractory bricks used in the combustion chamber of Wte plants. The PCMS encapsulated in the ceramic brick allows the installation of steam superheater in the combustion chamber by absorbing temperature fluctuations, while protecting them from high temperature corrosion. The installation of additional superheaters in the combustion chamber can lead to a significant increase of energy efficiency.

To investigate this possible solution, this paper adopts Dynamic Thermal Network method to model the WtE thermodynamics with and without the novel brick technology. Real plant information from Southern Italy is used as boundary conditions to locate the design points of PCM-based bricks. Then, a transient thermodynamic analysis is performed to compare the overall system efficiencies between these two models. From the result, there is an estimated 10% improvement in energy conversion efficiency on the waterwall by introducing the PCM-based buffer technology in WtE plant. The result shows that the PCM-based buffer technology is highly applicable and promising to upgrade the overall efficiency of WtE plants.

SDEWES2018.0109

Comparison of Sintering Condition and RF Plasma Discharge on the Conversion of Coal/biomass Fly Ash into High-Temperature Thermal Energy Storage Material

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Abstract

The management of solid waste becomes increasingly challenging with the accelerated growth in residency in Singapore. With limited land space, the disposal of waste in the current offshore landfill may no longer be available after 2035. Alternative utilization, such as high temperature thermal energy storage (TES) material, valorizes the waste to new resource, thereby reducing the need of virgin material and ensuring sustainability. Based on literature review, coal fly ash (CFA) has shown potential as high temperature TES material. In Singapore, coal is co-fired with biomass and the coal/biomass fly ash (CBFA) is partially reused. This research evaluated two different fabrication routes: conventional sintering and plasma processing. Unlike most studies whereby plasma arc is used to melt the ash at high temperature, in this study, a 13.56 MHz radio frequency (RF) plasma is used to control discharge parameters through in-situ diagnostics of active species density and temperatures. This allows for high throughput and uniform processing. An optimized plasma process could potentially reduce the total number of processing phases, with a lower energy budget for processing, while increasing the controllability of the processes to achieve the desired material properties. The chemical composition, morphology, and the heat capacity of the ceramics made from CBFA were evaluated. In this preliminary study, the RF plasma processed CBFA samples were found to perform better in heat capacity and energy density. However, sintered samples were thermally more stable. Further studies will be carried to investigate the mineralogy of the CBFA after different processes.

SDEWES2018.0133

Supporting the Strategic Decision-Making Process to Integrate Promising and Commercially Available Energy Storage Systems (ESS) Under Life Cycle Perspective

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Abstract

Energy Storage systems (ESS) are a challenging and promising approach to overcome the existing constraints concerning instabilities in the current energy supply scheme. Especially, energy generation from renewable sources possess a strong fluctuating and intermittent character that limits them to achieve a sustainable market penetration.

Among the developed ESS, mechanical and electrochemical storage systems are the most common and established ones in the available market. Despite their costs, technological maturity and market roll-out level, further developments have to be conducted to achieve better sustainable performances.

Focused on this aim, one innovative and attractive energy storage technology based on pH and salinity gradients is emerged to overcome existing barriers. This novel technology is attractive for stationary electrical energy storage and also might offer scalability (kWh up to MW-MWh) suitable for different capacities and applications. Besides the technical aspects, it does neither contain toxic chemicals nor scarce elements, which might result into a safer and more sustainable technology than other commercially available batteries. Due to the expected potentials, an exhaustive analysis of the new and conventional technologies might provide valuable information to elucidate potential environmental benefits. To conduct it, the first step consists on identifying key environmental issues of conventional technologies leading to stablish a baseline for the future comparison scenario.

Under this premise, this research is aimed to perform an environmental assessment (LCA) of four commercially available battery technologies [lead-acid (PbA), lithium-ion (Li-ion), nickel-cadmium (NiCd) and nickel-metal hydride (NiMH)]. Based on this methodology, key environmental indicators have been analyzed and EES have been environmentally characterized from a cradle to gate perspective.

Furthermore, this study critically examines data obtained by a comprehensive literature review (e.g., databases and journals) to attain an updated LCI database of the technologies under study. Preliminary LCA findings from this work highlight that Li-ion batteries have better environmental behavior than the others based on the more relevant indicators assessed by ReCiPe 2016 v1.1 midpoint method, Hierarchist version. Results provide support to decision making process carried out by developers involved within the new technology design.

SDEWES2018.0234

Packed Bed Regenerators Using Cascaded Phase Change Materials: Overcharging and Possible Solutions

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Abstract

In this paper, packed bed regenerators using different phase change materials cascaded in series for cold energy storage are investigated with specific focus on charging behaviour. Indeed, when one phase change material has significantly different thermodynamic properties than the others, or when flow rate of heat transfer fluid which contains cold energy to be stored is low, there can be an undesired scenario of overcharging certain phase change materials. This scenario subsequently leads to wastage of cold energy, especially when the phase change material meant for high grade cold storage is overcharged. Two solutions are suggested such as changing the encapsulation size of the affected phase change materials or increasing the storage capacity of the phase change material, or combining both of them. It is found out that increasing the storage capacity alone can solve the overcharging problem, with an improvement on the storage capacity of the regenerator. However, this increase in storage capacity also increases overall charge time of the regenerator. When incorporating both increase in storage capacity and encapsulation size of the affected PCM, the increment in storage capacity is less, but it brings an advantage of slighter increase in the overall charge time of the regenerator. It is also proven that in any of the cases, the efficiency in recovering or storing the high grade cold energy, is improved compared to the baseline cases.

SDEWES2018.0453

Energy Storage Systems for a 100% Renewable Power Supply: a Closer Look on Hydropower

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Abstract

For reaching highly renewable power systems, energy storage systems (ESS) are widely envisioned as a structural solution. Recent studies show how a sound combination of ESS can effectively offer a minimum cost solution for balancing the energy fluctuations in 100% renewable systems. Hydropower dams can also contribute to that task, but will likely operate in even stronger hydropeaking schemes (i.e. massive fluctuations in flow releases) that deteriorate the ecology of the downstream rivers.

In our study, we design a renewable power system and pay special attention to hydropower plants. We apply a linear optimization (for expansion planning) to Chile, modeling one target year with an hourly resolution. The existing hydropower park is fully represented. From there, we obtain the investment decisions of ESS and renewable generators, as well as the hourly operation of each hydropower plant.

In a scenario analysis, we show the role of hydropower in balancing energy fluctuations. We further illustrate the hydropower's compromise between providing flexibility and the (hourly) hydrological alteration. Finally, we put forward a trade-off curve (Pareto) between limiting hydropeaking and the costs arising from alternative flexibility sources (storage devices).

Including hydrological alteration criteria in expansion planning of power systems is novel and could potentially reduce human pressure on sensitive freshwater ecosystems below dams. Our findings are relevant for policy and decision makers in energy and eco-hydrology.

Energy and emission markets

SDEWES2018.0003

Challenges of the Electricity Sector in Spain: Analyzing Some Possible Change Scenarios Using a Computable General Equilibrium Model

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Abstract

A current problem in several societies is the realization of a sustainable development strategy especially in the context of balancing economic and environmental sustainability. In terms of environmental sustainability, renewable energy sources are recently becoming critical as societies attempt to address the problem of global warming. However, in spite of the importance of the electricity for the functioning of any economy, in the Spanish electricity system there exist some issues, which could be improved, such as the fact that its imports and exports are really low.

As is well-known in the literature, computable general equilibrium (CGE) models are a really good tool to study energy sector. In this paper, we develop a static computable general equilibrium model for Spain for 2013. The model has 72 productive sectors, ten of which are energy sectors, three consumers and two productive factors, labor and capital. The production function is a nesting production function taking into account the current structure of the electricity sector in Spain. Inside the energy sector, we distinguish electricity and non-electric energy. The electricity sector is divided into generation, transmission, distribution, commercialization and related activities. The generation activity is further disaggregated into wind, nuclear, conventional thermal, solar and other types and hydropower. The non-electric energy is also divided into Gas and Coke and petroleum. In the demand side, we also distinguish between energy and non-energy goods, as well as energy for house, energy for transport and electricity. The model is calibrated on a previously developed social accounting matrix (SAM) with this detailed disaggregation, the same as the model, for Spain for 2013.

In order to improve some of the issues of the electricity sector in economic and environmental terms, we plan some change scenarios. Concretely, we propose increasing the integration with the European network for increasing the commerce with the rest of Europe and, as a consequence, the competition among electricity utilities. Taking into account the environmental sustainability, we also propose the increase of the use of renewable energy sources, by, at the same time, decreasing the use of brown energy sources. And, finally, we propose to increase the competitiveness of the Spanish electricity sector.

Preliminary results suggest that the electricity subsectors are heterogeneous because not all the sectors are affected in the same way nor in the same sense. For example, there are some electricity subsectors in which, in the first scenario, when increasing the exports, the rebound effects are very significant. This heterogeneity of the electricity subsectors indicates that policy measures should take into account these differences between subsectors when implementing economic policies.

SDEWES2018.0051

Do Near Cost-Optimal Energy Scenarios Offer More Equitable Energy Futures for Swiss Municipalities?

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Abstract

The Swiss Energy Strategy aims at drastically increasing electricity produced from renewable sources until the year 2035. In a densely populated country such as Switzerland, this poses the question on where to best site these newly built power plants, while keeping costs, feasibility, environmental impacts and public acceptance in mind. Traditional cost-optimal spatial energy systems modelling suggests allocating power plants to regions with the highest resource availability and lowest cost. This, however, neglects possible options that might become cost-optimal in the future or may better serve municipality-specific interests. By exploring 2000 near-optimal scenarios for each of the 2403 Swiss municipalities, we investigate which municipalities are dominated by only several energy technology options and which ones have a more diverse choice for the future. We investigate if diversity in power plant types and their spatial allocation leads to more equitable futures across municipalities at still acceptable total system cost. We perform our analysis on a spatially-explicit bottom-up energy model for all Swiss municipalities. Preliminary results show that near-optimal strategies lead to more equitable results with only small tradeoffs in economic efficiency, but gains in terms of equity and potentially public acceptance.

SDEWES2018.0067

Reserve Provision by CHP Units and its Impact on Equilibria in Spot and Reserve Markets

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Abstract

There is a broad consensus that the energy transition planned in Europe, along with an increasing share of renewable energy sources, demands a sufficient number of flexibility providers. The established flexibility procurement mechanisms, notably the reserve markets, are expected to reflect the cost of flexibility provision. As more flexibility is needed – given a higher resulting uncertainty of residual load levels – prices for such provision are expected to rise. In recent years, however, reserve provision prices in Germany have shown a decreasing tendency, despite overall reserve demand remaining constant.

This contribution proposes to analyse first the equilibrium pricing of reserve power against the electricity spot market in a stylized setting. A fundamental market model is used to analyse the price effects of reserve flexibility from Combined Heat and Power (CHP) entering both markets, using 2016 data as input.

Four cases are analysed to assess the effects of different reserve market characteristics. In Case 1, CHP plants may not provide secondary reserve for the reserve market and a stylized heat demand curve is considered as operating restriction of CHP plants in the spot market. Case 2 allows reserve provision by CHP plants, but models these plants without heat restrictions. Case 3 considers the combination of the stylized heat demand curve and reserve from CHP plants. Case 4 extends Case 3 by 100 small CHP power plant pools, analysing their additional effect on reserve prices.

From June 2018 on, secondary reserve in Germany will be auctioned in four-hour tenders, instead of the current weekly peak/off-peak auction design. We therefore compare the results to an alternative auction regime with the same demand, but four-hour reserve provision tenders to reflect upcoming market design changes.

Our approach leads to spot prices at a similar mean level compared to historical data, with MAE values in a range from 6.13-7.42 €/MWh for all cases. The positive reserve price levels in this approach also compare to mean historical price levels. The price lowering effect of flexibility provision from CHP is clearly identifiable, underscoring the importance of explicit modelling of heat demand restrictions. A change of the reserve tender regime towards 4-hour tenders further lowers positive reserve prices in all cases. As a result, low reserve price levels may be expected to persist in the medium term despite the expected increase of intermitting generation.

SDEWES2018.0204

Cost of Achieving Emission Limits in Coal Burning Power Plants Under the Last Best Available Techniques Regulation Amendment: the Evidence from National Microeconomic Data

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Abstract

New emission standards under the Integrated Prevention and Pollution Control (IPPC) Directive came into force in July 2017. Especially coal burning power plants struggle, because they invested in new abatement technologies, but these are mostly not sufficient to meet the new emission standards. The situation led to lawsuits against the European Commission regarding the executive decision laying down the Best Available Techniques Conclusions. The paper presents a unique analysis of marginal abatement costs using detailed micro data on power plants in a situation of gradually tightening emission limits for nearly 50% of the installed thermal power capacity in the Czech Republic. The paper argues that the real marginal abatement cost under the new regulation is approximately six times higher for SO_2, 4–40 times higher for NO_x, and at least four time higher for PM than marginal costs associated with previous emission limits. The paper argues that most of the current work on the topic use a too general approach, which leads to noticeable underestimation of the costs of regulation.

SDEWES2018.0292

Brazilian Market Forecast for Carbon Dioxide Utilization

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Abstract

Several international agreements, focused on regulating greenhouse gas emissions in the atmosphere, were created due to the growing concern related to the climate change accomplished by human action. Although CO_2 is not the most toxic gas, its emissions account for more than 70% of total GHG emissions and, among the CO_2 emitting sectors, electricity generation accounts for 25% of global emissions. CO_2 emissions from Brazilian power plants motivated its mapping, as well the performance of a local market analysis for potential products from CO_2 chemical conversion. The behavior forecast of this market for 2018 was also calculated. Among the studied products, urea and methanol are the most imported. The import trend (kton and cost) for 2018, compared with last year, is for urea reduction and methanol increase. Regarding exports, propylene oxide stands out, which is expected to increase this year.

SDEWES2018.0621

Competing Market Regimes: When and Where are Supply and Demand Able to Shake Hands? A Case Study of the Danish Energy Transition

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Abstract

Like any other economic systems, the energy system can be analysed as supply and demand that clears through transactions in a market arrangement. The energy market arrangement is a complex institutional construction of trading rules, taxes, subsidies and other payment structures that allocates physical and financial streams. It takes a concrete institutional economic analysis to understand what kind of development and efficiency the particular market arrangement promotes.

While supply and demand forces always find each other in a market, the market arrangement is never neutral as its institutional construction promotes or prevents specific supplies and demands. The market arrangement is a political economy.

An interesting example of such political economy is the Danish energy economy that has accumulated a large renewable capacity in its electricity system. In 2017, the wind power and photovoltaic share of electricity consumption corresponded to 45 percent.

While the introduction of supply side policies—such as feed-in tariffs--has been subject to a lot of political attention, policies for the specific demands which meet this supply has not. Though the demand side is political, it has not been the subject of politics.

In the perspective of technical system analysis, the distribution of electricity demands becomes increasingly important as the shares of variable renewable energy expands. For example, Smart Energy System designs utilises specific electricity demands to balance the system while it reduces other demands.

From an economic perspective, supply and demand should be allowed to shake hands where value is maximised. But which specific supplies and demands that are able to meet in the market is determined by its institutional arrangement. This paper carries out a case study of the conditions for alternative market regimes in the Danish energy system. The different market regimes are linked to different technical development paths.

First, the paper investigates the institutional conditions for competing energy demands and relate them to technical system analysis. This analysis includes both current volumes as well as real energy prices. Second, the economic efficiency of the current institutional conditions is analysed in the perspective of technical system analysis. Third, the socioeconomic losses of the current institutional conditions are quantified.

Analysis and design of systems towards sustainable energy scenarios

SDEWES2018.0053

CO2-EOR and CCS: an Environmental Economic Trade-Off Analysis

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Abstract

Although CO_2 Capture and Storage (CCS) is considered a key solution for CO_2 emission mitigation, it is currently not economically feasible. CO_2 enhanced oil recovery can play a significant role in stimulating CCS because of additional oil revenues. However, CO_2-EOR also involves an additional environmental impact. Current literature on the evaluation of CO_2-EOR either focus on the economic or the environmental impact but never integrate both. We present an integrated analysis that shows the trade-offs between the economic and the environmental impacts for different potential CO_2-EOR scenarios in the North Sea region.

The system under evaluation consists of an electricity producer and an oil producer. We evaluate four scenarios: in scenario 1 the oil producer only produces primary oil and the electricity producer invests in CCS. The CO_2 is stored in an aquifer. In scenario 2, the oil producers extends its primary oil production by CO_2-EOR, using CO_2 captured by the electricity producer. The excess CO_2 captured is injected in an aquifer. After the CO_2-EOR operation, all the CO_2 captured is stored in the aquifer. In scenario 3, the oil producer also applies CO_2-EOR, after which CO_2 captured by the electricity producer is injected in the oil reservoir. Excess CO_2 captured by the electricity producer is stored in an aquifer. In scenario 4 the oil producer also extends its primary oil production by CO_2-EOR, but there is no storage after the CO_2-EOR. For each scenario the environmental and economic impact are calculated in terms of Global Warming Potential and NPV.

Scenario 1 results in a GWP of 5.74 Mt CO_2 eq. and a negative NPV (-792 M€). When CO_2-EOR is applied with subsequent storage by the electricity producer in an aquifer, the NPV turns positive (213 M€) because of the additional oil revenues. The GWP however increases (11.03 Mt CO_2 eq). For scenario 3, when CO_2-EOR is followed by CO_2 storage in the oil reservoir the NPV is a bit higher (220 M€) and the GWP is a bit lower (10.96 Mt CO_2 eq). Scenario 4 has the highest NPV (512 M€) but also the highest GWP (35.03 Mt CO_2 eq). We show that although CO_2-EOR followed by CCS comes at a cost for the oil producer, it reduces the environmental impact of EOR and keeps the NPV positive. Furthermore, it is shown that it is more environmentally and economically beneficial to use the depleted oil field for additional CO_2 storage rather than to abandon it and store the excess CO_2 in an off-shore aquifer.

SDEWES2018.0202

The Role of Bio-Methane Production in the South Mediterranean Area to Achieve a 100% Renewable Energy System by 2050

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Abstract

Campania Region has one of the highest Renewable Energy potential in Italy. This is confirmed by almost reached targets that the European Commission and the Italian Burden sharing have settled for the regional government. Despite this high potential, the lack of an integrated strategy between the Regional and Municipal governments allowed entrepreneurs and industrial groups to operate a deregulated exploitation of the resources of the territory.

Aim of the work is to define a possible energy strategy to fulfil a reliable transition from the current energy system to an enhanced one in 2050, by the integration of local renewable resource and investigate the role of regional biomass of the region. In order to validate the results, a reference model of the system has been built from Regional and National databases; therefore, three future scenarios have been modelled for comparison purposes. Different software have been used in order to find a new integrated renewable energy system: the software EnergyPLAN has been used to design the whole systems, while GIS and TRNSYS have been used to detail the energy system locally and dynamically in order to achieve more realistic results. The results obtained show that the scenario set by 2050 does not allow to achieve the objectives of reducing of 80% the GHG emissions. From the 1990's value it is forecasted a reduction of 65%; while the share of renewable energy is almost 47%. However the authors show, the role that biogas and bio-methane might play in order to obtain a complete decarbonisation of the territory.

Energy and economic analyses underline that is possible to reach a 100% decarbonized territory by 2050 if important changes will take place, integrating bio-methane from local biomass in the sector in the transport and residential sector.

SDEWES2018.0451

A Multi-Objective Optimisation Approach to the Prospective Development of the European Power System by 2050

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Abstract

This paper reports the recent work carried out to engage both environmental impact and economic indicators on the prioritization of ‘dispatchable’ technologies in the European energy mix up to 2050. Those two contradictory indicators are incorporated in a multi-criteria optimization leading to iterations of two scenario: business as usual and 2 °C climate policy. The results present the evolution of the climate change emission versus the operational costs of the power system up to 2050. The yearly electricity mix evaluations allow assessing the long-term development of the European energy system, where a focus is done on variable renewable energy production. It is shown that policy-only solutions, associated with a traditional cost-oriented optimisations, have a limited impact on helping the power sector to reach emission levels targets. Integrating the objective of reducing emissions to the management of power plants would reduce emission. The counterpart is that the system electricity price tend to increase faster thus implying increased social costs.

SDEWES2018.0537

Low Emission Mini Cogenerative Combined Cycle for Naval Applications

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Abstract

The theme of energy production with low environmental impact together with that of energy recovery, cogeneration and / or combined cycle, will have, in the near future, high potential of development also for the production of energy on board ships during navigation and during port operations. The levels of polluting emissions allowed by international regulations will become increasingly stringent and, following a trend already underway, will require the implementation of innovative plant solutions in order to reduce fuel consumption, promote any form of energy recovery and, above all, limit polluting emissions. The containment of pollutant emissions can be achieved through the use of an innovative mini gas-steam combined cycle with thermal energy cogeneration to feed the ship thermal utilities, in place of or alongside the electric Diesel engines currently used. The reduction in fuel consumption linked to the high performance of the combined cycle, allows a reduction in polluting emissions, CO2 production and thermal losses into environment. Apart from the significant reduction of nitrogen oxides due to lower temperature combustion than the Diesel engine, the cogenerate application (electric power, heating and cooling) and the combined system (steam cycle with steam turbine) is much more favorable with the gas turbine as first engine, rather than with the Diesel engine that disperses a significant flux of thermal power.

The first phase of the work is focused on the definition of the architecture of the plant. During this phase a set of parameters of the components of first attempt has been defined, to which a study aimed at optimizing the performance of the entire cogeneration cycle is combined. Optimal distribution of pressure and temperature and repartition of power between GT and ST have been identified. The second phase is focused on the choice and on the sizing of the individual components, with the aim of maximizing the efficiency of the machines and reducing overall dimensions and weights as well as guaranteeing the possibility of extraction of the required amount of steam for the onboard users. The basic mini-cycle consists of a GT of about 1.5 MW and a ST of about 0.5 MW, but the configuration is partially modular with specific cost reduction, operating flexibility and efficiency improvement in case of larger power required. Considering, for example, a demand for electric power of 8 MW, this can be satisfied by a battery of 4 mini GT of 1.5 MW each (top cycle) and a 2 MW ST (bottom cycle). Thanks to the cogeneration of steam released by the ST, it is expected that, compared to an overall electricity yield of 33%, it is possible to achieve a total return (thermal + electricity) of 80% (24 MW fuel burn, 6 MW gas turbine , 2 MW steam turbine, 13 MW useful steam, 2 MW lost into atmosphere).

SDEWES2018.0620

Design Optimization of Microbubble Pump Using Numerical Optimization Technique

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Abstract

The microbubble generator for water treatment is widely used in industrial wastewater treatment such as water purification technology, mineral processing, natural ecology restoration, bio-pharmaceutical production, fine chemical reaction, ozone water disinfection, and so on. The microbubble pump, which has a regenerative impeller, can be highly likely to be used in the industrial fields described above due to have many advantages compared with the typical microbubble generator. Aim of the present work is to optimize the shape of impeller of a microbubble pump to enhance the hydraulic performances using surrogate model. Hydraulic performances of a microbubble pump have been analysed by numerical simulation and experimental measurements. The experimental test rig of the microbubble pump has been developed to investigate the performances of the microbubble pump, such as air and water flow rate, pressure differences and torque. Three-dimensional Reynolds-averaged Navier-Stokes equations have been solved to analyse the flow characteristics of the microbubble pump. The numerical results for the microbubble pump have been validated in comparison with the experimental results for the same conditions. The serpentine-shaped impeller of the microbubble pump has been obtained first before the optimization procedure base on the previous study. Three parameters, the height of hub, thickness and number of blades for the serpentine-shaped impeller have been selected as design variables for the optimization. The objective function has been defined as related to pump efficiency. The results of the optimization show that the objective function values of the optimum designs obtained by the numerical optimization techniques have been improved from that of the reference design.

SDEWES2018.0635

Optimization of the Selection of Heat Sources for Low-Energy Buildings

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Abstract

The paper presents a multi-criteria analysis of the methods of supplying low-energy buildings with heatfor Polish climatic conditions.Two methods have been selected for optimization: "weighted sums" and "to goal" .For this purpose, four criteria have been formulated regarding energetic quality, economic efficiency, environmental impact and the coverage of renewable energy for heat demand for heating and hot water production.The results presented are examples of many of the analyzed buildings and technologies used .The simulation was carried out for a wide range of source variants differing in the scope of energy acquisition.The sources of heat for buildings are mixed systems having in their composition both installations using renewable energy (solar collectors, heat pumps, photovoltaic cells) as well as conventional heating sources in the form of, for example, gas boilers.

The use of two decision support methods gave similar results, though not identical. Both methods point to the problem of selecting devices for powering buildings with a reduced energy demand. The basic series of types are in larger power ranges. At the level of analysis of investment outlays due to too high costs of devices with very low power, devices from a typical series of types were used, which adversely affects the results of multi-criteria analysis. No change in investment expenditures disturbs the chart. It is necessary for manufacturers of heating devices to adapt the devices to buildings with a reduced demand for heat. The current offer does not include sources with low heat demand. And available devices are too expensive. Multi-criteria studies at the level of source selection showed that there is a problem of oversizing the installation. Which is associated with too high financial expenses. In the case of the 15-20 year horizon, it is too short period of time for it to be possible to obtain the profitability of such a source. For the 35-45 year horizon, profitability has a chance to be achieved.

Proper multi-source balancing results in a reduction of investment outlays by as much as 30-40%. Heat source working in an oversized system works on parameters with too low load, which adversely affects the operation and life of the source. The use of heat accumulators reduces the working time in conditions of peak demand for heat in the morning and evening hours. The results presented are examples of many of the analyzed buildings and technologies used.

District heating and cooling

SDEWES2018.0114

Assessing the Flexibility Potential of the Existing Norwegian Hydropower Resources When Shifting from Individual Electric Heating to District Heating Using Energyplan

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Abstract

As Europe moves towards renewable energy production, reservoir and pumped storage hydropower stands out as two of few technologies that can provide dispatchable electricity production and thus supply side flexibility in the future European energy system. This has provided background for several studies investigating the flexibility hydropower can provide cross borders, with particular focus on the Nordic hydropower resources. Of all European countries, Norway is the country with the largest hydropower resources and storage capacity, and has in both literature and media been referred to as a future green battery for Europe. However, Norway is also a country with a highly electrified heating sector, which means that in winter, when reservoirs are at their lowest level, there is also a high electricity demand within the country. This paper analyses how a shift from individual electric heating to district heating can potentially effect the flexibility the Norwegian energy system can provide to Europe. Three scenarios are constructed: a 2015 reference scenario and two scenarios with a 25% shift from individual electric heating to district heating based on biomass and heat pumps for production, respectively. The analyses are conducted using the simulation tool EnergyPLAN, taking departure in a reference scenario of Norway based on national statistics from 2015. Results show that a shift from individual electric heating to district heating can decrease the maximum load on dammed hydropower facilities, thus freeing up capacity for potential export to Europe. Furthermore, results show that the dammed hydropower facilities are able to balance the electricity demands in all hours of the year, but that there is an increased need for export when shifting to district heating due to a lower electricity demand and the need to drain hydropower storages to avoid overflow. All scenarios are able to handle smaller increases in import from Europe, but a shift to district heating decreases the amount of import the system is able to handle under the modelled conditions.

SDEWES2018.0331

Assessment of a Combination of Three Heat Sources for Heat Pumps to Supply District Heating

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Abstract

This paper reports a study on how hourly temperature variations of different heat sources influence the seasonal coefficient of performance (SCOP) of heat pumps (HPs) when supplying district heating. The considered heat sources were: groundwater, seawater, air and a combination of the three. The system included HPs, an electric peak load boiler and short-term storage. Linear programming was used to minimize annual electricity consumption of the system. This process also determined the optimum capacities of the HPs using different heat sources. The study was based on data for the area of Copenhagen, Denmark.

The results showed that the SCOP of seawater and air HPs, considering heat demand variations, was 11 % and 15 % lower, respectively, than their arithmetic mean performances. For a combination of heat sources, the optimum proportions of HP capacities were: 63 %, 14 % and 23 % for the groundwater, seawater and air HP, respectively. The SCOP of such system was found to be 3 %, 6 % and 11 % greater than the SCOP of a system using the heat sources individually. The SCOP depended on the climate region, total installed HP capacity and which building type was supplied.

The results indicate that a maximum system performance may be achieved for HPs based on a combination of different heat sources. In this way, the heat source resulting in highest performance for each period was preferred to use.

SDEWES2018.0341

Reducing Carbon Emissions of a Growing City Through Spatial Energy Consumption Planning – a Case Study of a Data Center with Waste Heat Recovery

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Abstract

The role of cities in climate change mitigation is central. Accordingly, cities are introducing municipal energy system development plans in order to respond to national climate policies. The actions most often suggested are to replace fossil fuels with renewable energy sources and to reduce regional energy consumption. However, energy system and urban development processes are typically separated within the city organizations although they are deeply interlinked, which may lead to contradictory actions or omission of potential mitigation opportunities through more complex system dynamics. The purpose of this paper is to present a spatial energy consumption-planning concept to urban development processes with a case study demonstrating one such dynamics-based mitigation opportunity. The paper studies GHG implications of spatially located new energy consumption (a data center) into existing urban structure. The study finds that although a new major electricity consumption unit was added to the system, the absolute GHG emission of the energy system were reduced due to correct spatial consumption planning. The spatial location of the consumption unit was chosen so that the waste heat was technically feasible to be utilized in municipal energy system's district heating network. Without the waste heat recovery, the city level direct GHG emissions would have increased by 4 833 tCO_2eq a year. However, due to spatial consumption planning the GHG emissions of the system decreased by 1 800 tCO_2eq. Emission savings occurred because natural gas-based district heating production was replaced with heat pump upgraded waste heat from the data center. Study concludes that the spatially sensitive planning of major electricity consumption units, e.g. data centers, offer an unexpected option for climate mitigation. The core characteristics of spatially suitable locations are district heating network with major heat transfer capacities, fossil based local heat production, electricity grid containing low carbon production, heat is demanded year around, and finally, that the urban structure is flexible enough for locating new electricity consumption units. Finally, it is suggested that such potentially suitable locations should be identified nationally and utilized when new electricity consumption unit are planned.

SDEWES2018.0412

Heat Roadmap Europe: Towards EU-Wide, Local Heat Supply Strategies

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Abstract

The heating sector of Europe is characterised by great diversity, which results in considerable difficulty in formulating common strategies. One of the main hurdles for the formulation of those are asymmetric data availability and standards in this field. As part of the Heat Roadmap Europe project, quantities and locations of heat demands, efficiency potentials, excess heat and renewable energy resources, as well as heat supply strategies are being formulated. The objective of the present paper is to develop a method for the preparation of a quantitative basis for local heat supply strategies. As no detailed spatial data on heat demand and supply exist for all of Europe, such are to be generated by means of a combined top-down and bottom-up modelling approach. First, heat demands are spatially disaggregated using spatial statistics. Second, spatial morphology is used to prepare a zoning of heat supply into individual and collective heating. Then, using linear heat demand density as a main parameter for district heating (DH) network efficiency and investment costs, the economically feasible DH share of prospective areas of collective supply was mapped using average costs for those EU member states, which constitute 90% of the EU heat demand. In the intermediate zone between urban and rural areas, DH may be feasible in the future, in particular if regulatory measures apply. For prospective DH areas, agglomeration of smaller areas to larger clusters were studied. Finally, the temporal and spatial availability of industrial excess heat was appraised. Access to renewable energy sources suitable for DH such as geothermal, large-scale solar thermal, as well as marginal biomass, was analysed. The result is a spatially coherent, comprehensive, and detailed set of heat supply strategies comprising of potential market shares of individual vs. district heating, including the potential sources and supply of DH in a temporally and spatially discrete manner. The findings indicate that among the most heat consuming EU member states, up to 71% of heat demand in urban areas can be met with DH, of which up to 78% can be covered with excess heat, while the remainder to the greatest extent is possible to cover with low enthalpy and marginal renewable energy sources. The conclusion points to the possibility of a largely de-carbonised heat sector as part of a smart energy system for Europe.

SDEWES2018.0604

Methodology for Heat Requirements Estimation for Rural Areas in Poland

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Abstract

This paper takes a starting point in the determination of possible spatial connections between sources of excess heat or energy sources that can be harvested and consumers requiring heat with the aim of introducing co-generation or energy recovery units to connect them. The idea is that e.g. a farm may have excess heat or waste that can be used for heat generation and that, if there are enough consumers in the surrounding area, it may be beneficial to turn the farm into a supplier. In rural Poland, farms are the most common type of industry, which tends to have excess heat and/or animal waste. In order to determine the possibilities of these connections, it is necessary to gain insights in on the one side the available sources of heat and potential energy sources for heat generation, and on the other side in the amount and the location of heat demanded in the vicinity.

A first step, and the core of this paper, is determining an efficient procedure to uncover the heat demand under the circumstance of incomplete actual information. Thus, focus is on defining and gathering data for demand assessments. Current heat production in rural areas tend to be based on small private devices with a number of possible fuel sources, such as wood, coal, oil, and gas. It is not straightforward to estimate the heat consumed by household as it depends on many factors. There exist general statistics of heat demand for Poland as a whole but not on a detailed local level. Considering all available data sources about the number, distribution and size of the buildings, and especially households can help establish such a local overview. This includes e.g. Topographic Data Database, BDOT10k and Database of Land use and Buildings. Also, using data from research projects like the Danish Heat Atlas and their experience in the heat estimation we aim to develop the methodology to estimate heat demand especially suited for Polish conditions. The secondary aim is to limit the necessity of making costly surveys to obtain real data from citizens. The developed methods will be tested for a rural area in the northern part of Poland.

SDEWES2018.0619

New Tool for Planning District Cooling Systems

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Abstract

INDIGO project focuses on the means for evaluating the performance, benefits and potential of District Cooling (DC) systems. The newly developed tool supports the optimal design of new DC systems, the assessment of existing DC systems' potential for performance/efficiency improvement and the comparison with building specific cooling systems. Life cycle analysis (LCA) framework is used for economic feasibility and climate impact assessment. The main input parameters are cooling demand, cooling production, distribution network characteristics and available resources. As an output, the tool yields primary energy consumption, greenhouse gas emissions and costs of the system. The defined potential district cooling system can be compared with building and space specific cooling systems delivering the same cooling service. The results are reported as a diverse set of key performance indicators (KPIs).

Sustainability comparisons and measurements

SDEWES2018.0004

Environmental Sustainability of Small-Scale Biomass Power for Agricultural Communities in Developing Countries

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Abstract

Agricultural wastes are readily available in farming communities and can be utilised for off-grid electrification as an alternative to diesel generators. Life cycle assessment has been used to evaluate the environmental impacts of these small-scale systems. Rice and coconut residues are considered for direct combustion and gasification, and livestock manure for anaerobic digestion (AD). Overall, AD is the best option for 14 out of 18 impacts. The results also suggest that gasification has up to 12 times lower impacts per kWh than combustion, except for resource depletion. Combustion and gasification have 85% to two times lower impacts than diesel generators, except for eutrophication, ecotoxicity and human toxicity. Depending on the feedstock, global warming potential of AD ranges from being 170% lower to 41% higher than that of the diesel generator. Overall, providing power from residual biomass in small agricultural communities would reduce environmental impacts significantly while improving waste management practices.

SDEWES2018.0005

Carbon Impacts of Current Production Systems, Lifestyles and Income Distribution in a Sustainable Development Pathway

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Abstract

The raising awareness on the current and future consequences of climate change has leaded to different international commitments aimed to ensure a sustainable development as the United Nations Framework Convention on Climate Change (UNFCCC), and especially the recent Paris Agreement (PA). These agreements provide a guide for all countries for the implementation of transformation processes towards sustainable goals. The European Union (EU) sets key targets related to cut emissions and improve energy efficient through a set of binding legislation for all production sectors and citizens. Production and consumption patterns in each country drive atmospheric emissions embodied throughout production chain, thus being a key element of climate policy as sustainable pathways can contribute to reduce emissions. However, disparities in income distribution and lifestyles between and within each country entails a different starting point for each country to reach their objectives.

In this work, we explore carbon implications of the current production and consumption patterns using an environmentally extended multiregional input-output model for all the EU Member States with different income categories. Specifically, we focus on impacts from the consumption behaviour of households under a critical assessment in a sustainable development pathway.

SDEWES2018.0007

Spatial Study of Water Footprints: a Gis-Mrio Analysis to the Ebro River Basin

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Abstract

Crop production is the most water demanding sector and it is high responsible of water footprint. In this context, the present work aims to evaluate the water footprint associated with each crop in the Ebro River Basin from a multiregional perspective. To do this, we built a multiregional input-output table for the Ebro River Basin considering five different regions into the basin. This table takes into account 18 different crops. We have also estimated the output and the water embodied at municipality level and we have created a GIS layer (Geographical Information System) whit this information to plot the water location and to depict maps of apparent productivity of water. From an environmental point of view and considering direct and indirect effects, main results suggest that increases on demand of wheat, corn and barley should be covered by Basque Country; and, demand increases in grapevine should be attended by La Rioja or Aragon, because they cause a lower water footprint. The present study also shows that it would be possible to produce the same output with a lower water footprint: to have a higher agricultural output with the same water footprint; or both.

SDEWES2018.0025

Environmental Impact Assessment Studies for Mining Area in Goa Using the New Approach

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Abstract

The Mining industry is a fundamental source for building infrastructures and an enabler for a country's growth. Over the last decade, the act of mining has been amongst the top in the list of human activities which has the most disturbing and catastrophic impacts on environment, therein extensively affecting the ecological, economic and social elements in the vicinity. There is an exigency for a pragmatic balance to exist between the global demand satisfaction of metal and environmental sustenance. In this paper, a comprehensive case study on Environmental Impact Assessment (EIA) of a mining site has been presented using the new approach. This new approach is an improved version of the traditional Matrix method, incorporating a modified version of Rapid Impact Assessment matrix (RIAM) integrated with Analytical Hierarchy Process (AHP), thereby knocking out the limitations in the existing EIA techniques. The data used in this study is an outcome of a broad survey conducted amongst the people associated in both direct and indirect ways to the project actions related to the mining industry. Hence minimizing issues such as assessors' reproducibility, subjectivity, and non-inclusivity of all stakeholders' opinion, this can contribute to misleading outcomes. This new approach delivers more precise and practical results for assessment of environmental impact data.

SDEWES2018.0131

Methanol Production from CO2 Hydrogenation and CO2 Rich Natural Gas: Assessment of Environmental Performance Through Exergy Analysis

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Abstract

Carbon dioxide (CO2) utilization to methanol has the potential to address relevant sustainability issues. It can be an economically feasible replacement of fossil raw materials for downstream products and can avoid greenhouse gas emissions. The thermodynamic stability of the CO_2 molecule, however, imposes harsh reaction conditions at the cost of a higher input of exergy, which is a thermodynamic property that links this knowledge area to the sustainability and environmental costs of a process. Exergy analysis is performed in order to assess exergy degradation and lost work associated to a chemical process. This paper evaluates an innovative route of CO2 chemical conversion to methanol in terms of exergy analysis, comparing it to the conventional synthesis gas (syngas) to methanol route. A novel framework is proposed for exergy assessment of processes with chemical reactions. The syngas is an intermediate and is considered to be produced by bi-reforming of CO_2 rich natural gas. On the other hand, the hydrogenation of CO_2 is a direct conversion performed in two serial reactors, the second at a higher pressure. Process simulations in ASPEN PLUS are conducted to obtain mass and energy balances, needed to support exergetic analyses. Since exergy is a property whose meaning is relative to some datum, a Reference Environmental Reservoirs (RER) must be considered. The RER is chosen to be the 25^{o}C Standard Atmosphere at sea level with composition in chemical equilibrium with air species and unsaturated in water with 2% mol. The RER is shown to be thermodynamically consistent but equipment inefficiencies are close to zero because of the very low RER chemical potentials of methanol and, particularly, hydrocarbons. Methanol produced by CO_2 hydrogenation retains about 35% of the exergy entering the process, while this amount is only 27% for syngas route, indicating a lower sustainability for the latter process.

SDEWES2018.0132

Life Cycle Assessment of Olive Oil: a Case Study in Southern Italy

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Abstract

Olive oil production is a relevant agri-industrial sector in terms of both production and consumption in Europe. According to the International Olive Oil Council , oil production has been growing in the last decades with alternate variability from around one million tons in 1990-1991 up to more than 2.3 in 2015-16. The largest contributor was Spain, reaching more than 1.4 million tons in 2015-16 followed by Italy with 474.6 thousand tons.

To approach the complexity on such a relevant and cross-cutting market sector, one solid approach towards the environmental sustainability of the olive oil sector is the application of the Life Cycle Assessment (LCA) methodology.

The paper builds on previous available knowledge and describes the results of a specific LCA based analysis of the production of oil in the region of Calabria, in southern Italy.

The goal of the study is to assess the energy and environmental impacts of different scenarios involving conventional and organic cultivations, plains and hills cultivations and involving different operating techniques. The study also aims at assessing the share of each life cycle step on the total of energy and environmental impacts.

The functional unit chosen for the comparative analysis is a glass bottle of 0.75 l of Extra Virgin Olive (EVO) oil. A “from cradle to gate” perspective was chosen. The analysis was developed according to the LCA standards of the ISO 14040 series.

The analysis is based on a field analysis developed in the last years in the province of Reggio Calabria between more than 50 enterprises and stakeholders of the field, representative of the whole Calabria region and of most southern Italy. The data used for the development of mass and energy balances are related to the years 2013 – 2015.

The results clarify that for all indicators that the first part of the life cycle – from the production, including the growth of the olive plant to the full production stage – is the most relevant, variable between 80.6% share in the case of the particulate matter indicator to the 99.64% in the case of land use (Hill – Biological agriculture scenario).

Relevant differences can be also traced for each specific indicator among all scenarios e.g. in the case of climate change all conventional scenarios cause impacts higher by one order of magnitude than the others, while. In the case of the cumulative energy demand, biological scenarios reach results more than double than the conventional ones.

Regional planning and cooperation

SDEWES2018.0062

Explaining the Changes in Household Electricity Consumption in Taiwan

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Abstract

This study investigates what are the main reasons that contribute to the change of household electricity consumption in Taiwan over the period 1985-2015. We verify that the changes of household electricity consumption are driven by different factors across these three decades. The increase in household electricity consumption is mainly attributed to the changes in the coefficients effect of the determinants. In particular, the coefficients effect of household size plays the most important role. The decrease of household size leads to electricity consumption per capita increases due to the loss of economies of scale. As for the contribution of the endowments effect, the number of air condition and household income are the most important factors. Moreover, we found that the coefficients effects of household size are the most crucial factor both for the high-income and low-income households. Therefore, the policy implications mean that the electricity pricing policy should take household size into consideration so as to offer electricity-saving incentives for these households with smaller family size. Besides, some strategies, such as improving energy efficiency of appliances and providing the subsidy for the investment in energy-efficient appliances, should have a higher priority.

SDEWES2018.0111

Spatial Bayesian Network for Making Probabilistic Predictions of Coastal Erosion in a Small Pacific Island

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Abstract

In this paper, an integrated approach combining Bayesian network (BN) with GIS is proposed for making a probabilistic prediction of coastal erosion and assessing the implications of adaptation measures, which may affect the interactions and trade-offs between diverse ecosystems services. A BN - a probabilistic graphical model - is developed to define the components of a coastal system and their causal relationships. The BN has a capability of using a range of qualitative and quantitative information into a single probabilistic model while GIS explicitly deals with spatial data for inputting, storing, analysing and mapping. The proposed integration of the BN with GIS using a cell-by-cell comparison technique (aka map algebra) provides a new tool to perform the probabilistic spatial analysis. To put this approach into context, a case study of Tanna Island in Vanuatu in the South Pacific is investigated. Based on the BN model, the rate of the island shoreline change is predicted by updating the probability of the coastal erosion rate. The most likely case with the highest probability is then selected as its prediction for the case of shoreline segment. Then, probability maps are created by transferring the results of BN back into GIS. In this way, the spatial distribution of prediction results for the island's shoreline change is mapped.

SDEWES2018.0125

Beyond Current Nationally Determined Contributions: Additional Mitigation Potential in Ethiopia's Transport Sector

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Abstract

To achieve the limit of keeping the global temperature increase well below 2°C and pursue efforts to limit it to 1.5°C, as agreed upon in the Paris Agreement, additional mitigation efforts are required. While Ethiopia's nationally determined contribution (NDC) is already quite ambitious, it is still inconsistent with the "well below 2°C" goal. This paper examines additional greenhouse gas (GHG) emission mitigation potential in Ethiopia's transport sector that could support going beyond the envisaged mitigation for transport in the Ethiopian NDC.

The paper sets the stage with relevant country information including a detailed analysis of Ethiopia's historic as well as its projected emissions. Subsequently, Ethiopia's mitigation policies and strategies are explored with a focus on the Ethiopian NDC.

Based on government documents and relevant literature, the paper then identifies gaps and options for tapping additional mitigation potential in Ethiopia's transport sector that go beyond the NDC. For this purpose, it provides an overview of abatement potentials identified by national strategies, points to co-benefits and barriers for implementation, and closes with suggestions for deepened and further action in the transport sector.

The paper finds that while Ethiopia has a comprehensive set of climate change mitigation policies and strategies that already cover all relevant sectors, and its NDC is quite ambitious, there is still additional mitigation potential to tap that could support efforts to go beyond the NDC's target. In transport, further action could focus on improving institutional and technical capacity, stakeholder involvement, and financial support regarding upfront costs. Additional mitigation could also be achieved by extending and improving public transit and rail networks. Additional measures range from avoiding traffic with an urban planning transition towards mixed use, compact, and poly-centric cities, improving rural and urban transport infrastructure, and increasing the modal shift to non-motorised transport and (mass) public transport.

SDEWES2018.0268

Projecting the Future Carbon Capture and Sequestration Potential from Reforestation: a Brazil Case Study

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Abstract

Since 1850, over 145 ± 16 PgC (μ ± 1σ) has been emitted worldwide due to land-use change and deforestation. Besides industrial carbon capture and storage (CCS), storing carbon in forestry products and in regenerated forest has been recognised as a cost-effective carbon sequestration option, with an estimated worldwide sink potential of about 50-100 PgC (15-36 PgC from tropical forest alone). This paper proposes the expansion of an energy system model (ESM) to be able to calculate future agricultural technology diffusion and its effects on land use demand. The model has been applied to simulate transitions in the Brazilian energy and land systems between 2010 and 2050. Different regions and biomes have been considered. Modelling outputs suggest that by 2035, Brazil has the potential to liberate up to 32.3 Mha of agricultural land (mainly from pasture intensification), reaching 68.4 Mha by 2050. Besides the reference case, and to understand the potential of former agricultural land on carbon sequestration and storage, two different sequestration scenarios exploring sugarcane expansion and reforestation have been explored. If a hypothetical sugarcane expansion policy is followed, by mid-century the largest sequestration rates would come from above and below ground biomass pools; however, it would have gradually released to the atmosphere around 3.3 PgC or 3.5% of the current Brazilian land carbon stock, mainly due to lower SOC carbon pools when turning pasture land into sugarcane crops. On the other hand, a reforestation-only scenario projects that by 2035 the baseline year carbon stock could be recovered and by 2050 the country's carbon stock would have been increased by 1.8 PgC, reaching annual net sequestration rates of 0.1 PgC y^{-1}. This is mainly supported by high C sequestration from the North, South-East and Centre-West regions.

SDEWES2018.0450

Transition Towards 100% Renewable Power and Heat Supply in Kazakhstan

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Abstract

Since 2011 the Kazakh government declares its commitment to energy system modernisation, promoting a more decentralised, balanced and environmentally friendly energy supply. The national agenda “'Low Carbon, Green Growth” aim is to become one of the world's most environmentally and healthy countries, with sustainable energy at its foundation. During the last 25 years Kazakhstan’s GDP increased by more than 5 times, mainly driven by fossil fuels export and energy intensive heavy industry. Between 2000 and 2015, the total primary energy consumption of Kazakhstan grew by 116% from 419 TWh_{th} to 904 TWh_{th}. At the same time, 70% of the energy generation infrastructure is in need of reinvestments and must be modernised or substituted in the next years. In order to avoid massive stranded investments and support sustainable economy growth, the transformation of Kazakhstan’s energy system towards 100% must be started soon.

In order to define the optimal trajectory of the energy system transition, Kazakhstan's power system was modelled with the LUT Energy System Transition modelling tool in 5-year steps from 2015 to 2050. The simulation was performed for the power sector and for the integrated system of the power and heat sector with 1-hour resolution for each year. The results show that the existing energy system of Kazakhstan can be transformed towards a 100% RE system by 2050. RE resources of Kazakhstan are sufficient to supply the energy needed for the sectors power and heat. A 100% RE-based power system will be lower in cost than the existing fossil-based system, the levelised cost of electricity in 2050 will be around 50 €/MWh. However, a 100% RE heat system integration will be far more challenging: balancing of huge seasonal heat demand without fossil fuels will require substantial investments in energy storage technologies. In this case, electricity cost in the integrated system will stay approximately at the current level, while cost of heat supply will increase by 50%. The transition will also require installations of significant power-to-gas capacities, in order to supply a carbon neutral fuel for the heating sector and industry. A low cost sustainable 100% RE system can be built by 2050, which is able to supply the power and heat demand of Kazakhstan.

SDEWES2018.0590

Strategic Urban Renewal for Long-Term Energy Saving in Cities: Case of Kitakyushu, Japan

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Abstract

Energy saving in building sector is critical for realizing a low-energy city. Beyond the energy use in operation, embodied energy consumption in construction is also an important source of CO_2 emissions. For energy saving, manufactures and consumers usually pay attention to improve energy conversion technologies, but have less interest in improvements of building envelope technologies, where the latter has long-term impact on total energy consumption. Furthermore, strategic urban renewal, including guided migration, facility relocation and neighborhood design, will substantially impact on future urban morphology and building distribution. Downscaling from a city to a building, long-term uncertainty should happen during complicated policy implementation, while previous studies usually focus on evaluating the impact of an individual policy that lacks an overall assessment on the total effect.

To fill the research gap, this study developed an integrated urban simulation model to estimate the impact on energy consumption from long-term urban renewal strategies in cities. Through a 4-dimension Geographic Information System (4d-GIS) database, survival curves of different type of building stocks are estimated, while an iterative simulation of future building distribution considering critical factors and an algorithm mechanism of building relocation and attribute changes is established with spatial analysis. Finally, building-related policies are input and tested as external or internal factors in scenarios. A hot-spot environmental city in Japan, Kitakyushu City, is chosen as case area.

Rough results indicate complicated synergy and trade-off between building stock management and energy-related policies, such as: (1) Promoting compact city planning and Net Zero-Energy Building (ZEB) can save energy to some extent, but the potential is offset by extended building lifespan and increased wooden houses; (2) Promoting wooden houses can substantially reduce energy consumption in construction, but it is offset by increased energy use in newly built detached houses; (3) Popularizing CLT (Cross-Laminated Timber) usage in buildings has perfect impact in reducing the total energy consumption, but its progression is limited by available material supply and social acceptance. Such scenario analysis can help in conducting a more inclusive urban planning for realizing low-energy cities.

Buildings 2

SDEWES2018.0052

Heating Energy Demand of Non-Residential Buildings Using Updated Degree Days in Italy

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Abstract

The weather is one of the main factors to be considered for the building design because it represents the most important boundary condition affecting the dynamic behaviour of the building during its useful life. One of the most representative climatic indexes is the Degree-Day (DD). The close correlation that exists between DD and the building energy required is valid only if the assessment of the energy demand has been verified for the same updated database that led to the DD evaluation. The authors, identified the relationship between DD and winter energy performance, determining some simple correlations to derive a preliminary evaluation of building energy demands. At the same time the study is aimed at verifying the importance of the climatic data used in simulation models. The authors calculated Heating Degree Days (HDD) using different climate files developing different relationships and different feedback between the HDD and heating energy demand evaluating the reliability degree by the correlation coefficients (R^2). For the extraction of these correlations, numerous dynamic simulations (13 building models, located in 15 Italian cities) on non-residential buildings characterized by high-energy performances and modelled on the Italian technical standard have been carried out. The high degree of correlation of each issued relationship, clearly prove that HDD is a good index for assessing the energy performance of a building.

SDEWES2018.0146

Correlation of Ventilative Cooling Potential and Energy Saving in Various Climatic Zones

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Abstract

The introduction of cool outdoor air can help in reducing the energy consumption for cooling during summer. Ventilative cooling potentials (VCPs) have been defined in various ways in the literature to represent potential cooling hours in specified outdoor temperature ranges. However, the energy-saving potential by ventilative cooling can differ between buildings in the same climatic zone depending on the buildings' thermal characteristics and system operations. In this study, VCPs are introduced with an index of temperature shift based on adaptive thermal comfort. This index can be determined based on the balance temperature difference of the buildings, which is defined as the heat gain in the building divided by the thermal transmission and air exchange characteristics of the building envelope under quasi-steady state conditions. The proposed method was also compared with those reported in the literature, including a computer-based VCP tool.

It is the objective of the present study to investigate the correlation between VCPs and actual energy savings via ventilative cooling. Simulations were conducted in an office building for a four-month period during summer to calculate the energy saved via ventilative cooling in comparison with that achieved with a mechanical cooling system. Eight cities representing four different climatic conditions were considered: tropical, dry, temperate, and continental. Our results revealed a strong correlation between the energy savings and the proposed VCPs in the case of a proper temperature shift estimation in all climatic zones. The computerized VCP tool also exhibited good correlation with the calculated energy savings and with the VCPs proposed herein.

SDEWES2018.0168

Combined Numerical Approach for the Evaluation of the Energy Efficiency and Economic Investment of Building External Insulation Technologies

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Abstract

The paper investigates the energy efficiency and the economic investment of different coating technologies adopted to improve the thermal insulation of a building's external walls.

The traditional coat insulation and the ventilated façade are compared and the effects on the energy required to maintain the same indoor temperature during a year time period are evaluated numerically. For the ventilated façade the option of opening and closing the air gap is also addressed and its influence on the thermal insulation on the summer and the winter seasons is estimated. Additionally, the energy efficiency calculations are employed to estimate the economic investment necessary to realize the different solutions.

The performance of the building insulation technologies are preliminary determined by means of a CFD simulation of the full 3D geometry of the building during two reference days within the year, that represent the extreme temperature and sun radiation conditions during summer and winter. The CFD modeling includes the effects of solar radiative heat transfer during the day and, furthermore, a multiband thermal radiation approach is adopted to capture the different nature of radiative heat exchange according to the light wavelengths. Thus, the CFD analysis is employed to calculate the total heat transfer coefficient of the building walls in each scenario and it is implemented in-house developed library based on the open source Open Modelica platform to simulate the energy requirement of the building during an entire year. The combined numerical approach enabled to determine the performance by the studied technologies in terms of electric energy and fuel consumption for the air conditioning and the heating systems to maintain a constant indoor temperature as well as the internal ambient comfort.

The simulations demonstrated that by adopting the two proposed solutions it was possible to save approximately 37% of the fuel required for the heating system and more than 51% of electric energy necessary to power the air conditioning system.

Finally, the payback of the investments for the different solutions are evaluated and the coat insulation resulted as the best trade-off between the energy efficiency of the building walls and the economic effort having a payback time close to 14 years.

SDEWES2018.0205

Air Quality in Schools and its Relationship with Building Design, HVAC Systems and Urban Location

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Abstract

Indoor air quality in schools has a direct impact in the performance and wellbeing of students. This paper shows the results obtained in an indoor air quality monitoring campaign in 9 different school buildings at the South of Spain. A set of primary and secondary schools was taken as a representative sample of the schools at the South of Spain, with a selected variety of ages, daily scholar schedules and building designs. This work is developed within a global project with the aim of identifying sustainable and affordable design solutions for new school building designs and building retrofitting measures. The monitoring campaign was developed in the spring season, with moderate external temperatures, in order to identify air renovation requirements related to the analysed elements. On this purpose, this paper focuses on the analysis of indoor CO_2, PM10 and PM2.5 profiles and levels, and their link to indoor temperature, humidity, occupation rates and existing manual ventilation measures. The results show a wide dispersion in CO_2 concentrations, with peak variations between 400 and 5000 ppm, and particulate matter fractions, with peaks variations between 1.3 and 11.8 µg/m3 for PM 2.5 and 2.2 and 27.1 µg/m3 for PM10. These variations are identified with the occupation rates, metabolism of occupants, with peaks before break periods, and ventilation actions. They are also related to particles, in all cases with higher indoor levels than outdoor levels. The values show that, for the representative sample under analysis, with adequate natural ventilation designs, Indoor Air Quality can be maintained under comfort conditions for the mild temperatures of this Mediterranean climate.

SDEWES2018.0314

Analysis and Comparison with Actual Data of Energy Requirements for Lighting in Buildings According to Lighting Energy Numeric Indicator

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Abstract

The optimization of lighting plants and, in particular, of their control system is a necessary action to achieve sensible goals regarding energy savings and comfort. Many methods voted to predict energy savings were developed and proposed by European standard, e.g. by the EN15193. This document investigates the accuracy and reliability three of these approaches to calculate the LENI (Lighting Energy Numeric Indicator). Authors present an analysis of the methods and the comparison between the obtained results and the measured figures. The data used to calculate LENI were measured in a laboratory located in Palermo (Italy) using two different control systems. Results show that the consumption values calculated using the methods suggested by the standard are affected by high errors. The ability to appreciate time-dependent daylight contribution effects on the system behaviour is weak.

SDEWES2018.0333

Lessons Learned from in Situ Thermal Measurements of Double Windows in Historic Buildings

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Abstract

The challenge of sustainable development and of global warming is worldwide acknowledged, and the existing building stock is an economical sector where it is possible to reduce significantly energy dependence and environmental impact. However, considering historic buildings any energy efficiency retrofitting strategy is a risk in terms of preservation of cultural heritage buildings and historic urban landscapes.

In this context, windows appear both as a crucial and weak point of these buildings because of their important impacts in the energy balance of buildings. In a first approach, new windows are systematically proposed in energy retrofit measures. However, because of the architectural and patrimonial constraints, windows replacement is not appropriated and other targeted techniques are needed to be set up. Another technical solution can be considered. This is about double windows which entail the addition of a second window to the existing one, restored if needed. Despite of the numerous historic buildings applications, existing scientific studies don't deal with this technical solution. They only deal with modern windows or laboratory test. That make rehabilitation case scattered and non-optimised. There is a knowledge gap between existing scientific studies and in situ application cases which has to be fulfilled.

This paper presents the results of four in situ thermal measurements of double windows integrated to historic buildings of the region of Lyon. The different contexts and set up are described. Physical outcomes are focused on three different fields: the thermal assessment of double windows, the influence of walls enclosure coatings and the impacts of occultation on enclosure temperatures. Besides, lessons learned from these experimental campaigns are discussed.

Energy planning

SDEWES2018.0035

Open Energy System Modelling with Urbs – Example Germany

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Abstract

The reorganization of the energy system from centralized to more decentralized systems imposes challenges on various areas from building to operation. Energy system models are a tool to give researchers as well as operators more insight into the working of the complex energy system. There are various energy system models and frameworks which have different focuses like unit commitment, expansion planning, energy dispatch or social welfare.

We decided to take urbs, as it is an open-source linear optimization problem which minimizes the costs for energy dispatch and expansion planning. Via the input file, commodities like solar, CO2 or the electricity demand can be defined and conversion as MIMO processes can be created. A typical example for such a process is a CHP plant which converts gas to electricity, heat and CO2. With the framework urbs, on the one hand energy systems for small towns which also take sectorcoupling into account have already been modeled, on the other hand even models for whole electricity systems of states like California including their neighbours have been developed.

For our study, we show the development of a model for urbs with the example of Germany. We present the modeling methods for collection and deriving open input data for urbs. This includes installed capacities, aggregated transmission lines, timeseries for the input of the renewable energy sources and the timeseries of the demand. Additionally, the tools which were developed during this process are provided for the aggregation of the open data. Furthermore, the validation of the used data and the developed model is shown.

At last, we show the application of the model via calculation of scenarios and give insight on how a future German energy system can cope with the arising challenges and the fulfillment of the climate goal.

SDEWES2018.0086

Evaluation of Electricity Storage Versus Thermal Storage as Part of Two Opposing Energy Planning Approaches for the Island Samsø

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Abstract

The planning of energy systems of islands is not only a challenge because of their remoteness and typical dependence on imports, but on the contrary also an opportunity to test and study supporting technologies in a limited scale. Either due to being completely off-grid or constrained through local bottlenecks – or simply to increase independence and security of supply besides other benefits – island energy systems should aim for a better integration of local resources and exploit their potential for local energy supply. Two trends can be made out in this regards: on the one hand, integrating renewable electricity by electrifying other energy demands and investing in Battery Energy Storage Systems (BESS). On the other hand, the integration of all energy sectors into a Smart Energy System (SES) with the conversion of renewable electricity to heat – thus enabling the usage of Thermal Energy Storage (TES). In this paper, these two potential paths are investigated through energy systems analyses using EnergyPLAN for the island of Samsø in Denmark.

SDEWES2018.0117

100% Renewable Energy Sources in Isolated Islands Through the Connection of Their Power Systems. Pico and Faial Islands, Azores

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Abstract

Implementation of renewable energy sources (RES) in small and isolated power systems, as is the case of islands, constitutes both a challenge and an opportunity. On one hand, these islands have an unquestionable need for primary sources that can replace fossil fuel's usage. Fossil fuels are not only more expensive than on the mainland but also of more difficult access. RES integration can help to improve the economy as well as the islands' ability to be self-reliable energy wise. On the other hand, RES intermittency originates problems of grid stability, as well as a mismatch between power demand and supply. These issues must be carefully addressed according to each island's peculiarities. The connection between isolated power systems can decrease the RES variability and, thereby, minimize the problems associated with their intermittency. Furthermore, linking all fossil fuel consuming sectors can help to shift demand and supply according to the system's requirements, following a smart energy system approach. This study examines possible paths for 100% RES islands, considering the overall energy system, and not just the power system. The Islands of Pico and Faial, in Azores, are used as case studies. Considering the interconnection of the power systems of these islands and a combination of biomass, municipal solid waste, wind, solar, wave, hydro, batteries and the replacement of internal combustion engines vehicles by battery electric vehicles with the vehicle to grid technology it is possible to reach 99.9% RES in 2050, with a decrease of 10% of costs per kWh of final energy in relation to the business as usual scenario for 2050.

SDEWES2018.0123

Energy Supply for Remote Philippine Islands: Sub-Marine Cable Interconnection Considering Local Bathymetry Compared to Renewable Based Mini-Grids

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Abstract

For archipelagic states such as the Philippines it is important to assess centralized and decentralized approaches for supplying electricity to its many and far flung islands. This study compares the feasibility of (I) submarine power cable interconnection and (II) renewable-based hybrid system development for 131 decentral energy systems. For (I) a geospatial analysis is conducted: an algorithm computes the optimized grid outline taking into account bathymetric and elevation models. For (II) an energy system optimization tool is applied. For each system the least-cost option in terms of power generation costs is computed, taking into account diesel generator, photovoltaics (PV), battery storage, and specific island electricity demand. The results show that for connecting the considered islands, a grid extension of 2,107 km by submarine cable and 2,089 km by land cable is required. The overall investment under the given cost assumptions sums up to 762 million USD for grid infrastructure alone, not considering the additional power capacity required to meet the demand of the newly connected islands. For hybridizing the considered systems, the overall investment costs under the given cost assumptions totals 707 million USD. This study serves as an initial assessment of centralized and decentralized energy supply strategies for remote islands of the Philippines.

SDEWES2018.0173

Development of Battery Energy Storage System (Li-Ion, Redox Flow, Sodium-Sulfur) Models for an Island Microgrid Optimizer

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Abstract

Increasing energy demand and increasing greenhouse gas emissions has led to the integration of renewable sources for energy generation, and battery energy storage systems (BESS) for energy storage and stability in energy systems. Such systems are subject to high costs especially when oversized, thus the need for size optimization. This prompted the development of commercial energy systems modeling and optimization software such as HOMER® Pro; however, the models used by these software, are generic and may fail to include the unique characteristics present in some components, especially for emerging BESS chemistries such as lithium ion, sodium sulfur, and vanadium redox flow. In this work, a free and module-based energy systems optimizer named Island System $LCOE_{min}$ Algorithm (ISLA) was developed. The software uses an iterative search space algorithm in optimization and specializes in using rigorous BESS models to obtain accurate results reflecting power losses inherent in each chemistry. The developed software was then validated using HOMER® Pro through a case study calculating the optimum sizes and corresponding power flows of PV-diesel, and PV-BESS systems on Marinduque Island, Philippines. Discrepancies observed were caused mainly by the difference of the models used by the proposed ISLA model with HOMER® Pro. The differences between the optimum sizes were consistent with the qualitative behavior of the BESS models used in the ISLA model. For further validation, SOC curves were also compared. Differences between the two software were less than 4% and were also consistent with the BESS models used; however, these differences have a significant effect on design of large-scale energy systems. Optimization with projected costs were performed and the long-term feasibility of these power systems are discussed. The PV-Li-ion system was found to be a feasible alternative to the pure diesel power system on the island due to its low price, reliability, and high renewable energy share percentage.

SDEWES2018.0316

Solving Reserve Location Problem in Modelling of Energy System Development

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Abstract

The active power in electricity system has to be generated at the same time as it is consumed. Disturbances in this balance cause a deviation of the system frequency from its nominal values. The highest frequency deviations are obtained in emergency situations when large generation capacities or interconnecting power transmission lines fall out of service. The adequate reserve capacities should exist in the power system to cope with such shocks, maintain frequency within the set limits and ensure system stability. Reserve capacities can be deployed within the system (synchronous area) under consideration or obtained from other systems (synchronous areas, blocks, and zones) via electricity transmission lines. In order to maintain an efficient and stable operation of the system, location of reserve capacities must be selected during system development planning but there is a research gap in the development of methods to represent reserve capacities in energy planning models such as MESSAGE, MARKAL, TIMES and similar.

The objective of the research is to improve methods for quantitative assessment and allocation of the reserve capacities using energy planning models.

The paper presents the enhanced modelling framework for estimating necessary reservation capacities, their allocation and maintaining reservation services in the power system, taking into account various types of reserve capacities (frequency containment reserves, frequency restoration reserves, replacement reserves) that can be provided by different power plants, alternating and direct current interconnectors, linking neighboring electricity systems (synchronous areas, blocks, zones) with increasing share of intermittent generation and/or implementing large units in comparatively small energy systems. The main attention is paid to the assurance of necessary reserve capacities.

Elaborated methodology for analysis of reservation options allows optimal reserve capacity allocation among energy generation sources and interconnectors simultaneously with energy sector development and operation analysis. It allows finding when and which part of any technology is used for commercial energy production, import or export and for providing reservation services of any kind. Incorporation of this methodology into mathematical models designed for energy sector development and operation analysis enables to solve the problem of optimal sizing of energy production units, energy import/export facilities, energy storages and similar technologies.

Biofuels, bioenergy and biorefineries

SDEWES2018.0066

Investigation of Various Biomass Drying Intensification Scenarios in a Packed Bed of Biomass: Experiments and Numerical Modeling

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Abstract

The energy production from renewable energy sources is one of the ways to achieve climate change mitigation. Biomass combustion is a promising alternative as a renewable energy source. In the power plants the efficiency of biomass conversion highly depends on the moisture content of biomass, which can reach up to 60 wt. % on wet basis (w.b.) or even more. Therefore, it is essential to optimize drying and combustion regimes of extremely wet biomass.

A two-dimensional numerical model that considers heat and mass transfer was developed in order to predict the heating and drying rates in stationary packed bed of wood chips with high moisture content. Particle configuration was resolved using volume averaging, where gas flow through packed bed was solved as gas flow through porous media. Model incorporated established porosity distribution function in corners and near wall areas, which let us to estimate gas flow rates in our model domain. The rate of evaporation/condensation in model depended on the internal particle parameters: moisture content and solid temperature, and the ambient air parameters: humidity and air temperature.

In the developed CFD model particle surface roughness was the unknown parameter and needed to be fitted. After fitting was done, model validated by experiments performed with a packed bed of wetted wood chips that was dried with the inflowing heated air of 50 °C, 100 °C, 150 °C, 200 °C for period of 140 min. It was shown that our model gives good match in case of 50 °C temperature of inlet air. However, drying rates in cases with higher inlet air temperature are overestimated and absolute moisture content deviation at the end of calculation of 200 °C case was 14.38 %. Also, considerable amount of water condensation in higher layers of packed bed were observed.

SDEWES2018.0094

Influence of Fuel Injection Settings on NOx Emissions from an Engine Fueled by Diesel Oil-Biodiesel Blends

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Abstract

Motivation for the paper

Biodiesel has received growing attention as an alternative to diesel fuel with the aim to reduce carbon dioxide (CO_2) and other regulated pollutant emissions. It can be produced from different sources, such as vegetable oil and animal fat. Diesel engine performance and emissions depend on several factors, however, NO_X and particulate matter emissions are still an issue for diesel engines, even considering the developments obtained in the new generations.

Objectives

This work analyses the influence of fuel injection characteristics on combustion, performance and emissions of a single-cylinder engine operating with blends of diesel oil and soybean biodiesel, in order to estimate NO_x emissions under different operation conditions.

What was done

The fuel injection characteristics – injection timing, injection pressure, number of injector nozzles and number of injections along the cycle – were investigated using the AVL Boost software. Prior to variation of the injection characteristics, the model was validated against experiments for a baseline engine condition.

How it was done and validated

A numerical study was performed using a dedicated engine cycle simulation software, validated by experimental data available from a 12.1 kW diesel engine operating at 25%, 50%, 75% and full load, and crankshaft speeds of 1500 rev/min, 2000 rev/min and 2500 rev/min. The varied parameters were fuel injection pressure, injector nozzle diameter and number of nozzles, injection timing and number of injections in a cycle.

Major results

The results showed that NO_X emissions were reduced by decreasing the injection pressure and the number of injector nozzles while increasing the nozzle diameter, retarded injection timing and applying two fuel injections instead of single fuel injection. The largest effects were noticed for changing from 5 nozzles of 0.12 mm diameter to 3 nozzles of 0.25 mm diameter when reductions of NO_X emissions from 51.5% (B100) to 57.8% (B10) were attained.

Conclusions

As a new outcome, this research indicates optimized values for those parameters to improve engine operation with blends of the three fuels here considered and allows to achieve a lower level of NO_x with its operation.

SDEWES2018.0112

The Catalytic Performance of Mg/al and Mg/fe Mixed Oxides in Transesterification in Flow Reactor

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Abstract

Many research groups look for a new kind of renewable fuel, which could replace the fossil fuel. Biodiesel is alternative fuel to petroleum diesel and can be the solution to increasing fuel consumption. Biodiesel is non-toxic, biodegradable, and sulphur-free fuel. It can be prepared from triacylglycerides, which are contained in vegetable oil, animal fats or waste cooking oils, by transesterification with alcohol. The transesterification is usually catalysed by homogeneous catalyst, which is not possible to reuse. The reusable types of catalysts such as heterogeneous or enzymatic catalysts are studied today.

This study is focused on the test of the Mg-Fe and Mg-Al mixed oxides, as heterogeneous catalyst, in the transesterification of rapeseed oil with methanol in the flow reactor. The major advantages of flow reactor are faster reactions, cleaner products, quick reaction optimization, easy scale-up and possibility to use online analysing of products. The mixed oxides were synthesized from the layered double hydroxides (hydrotalcites) by calcination at 500 °C with the constant molar ratio 3:1 (determined by ICP). All synthesized materials were characterized by several techniques such as X-ray diffraction, thermogravimetric analysis, specific surface area, temperature programmed desorption (TPD), diffuse reflectance infrared Fourier transform spectroscopy and SEM. The characterisation methods confirmed the formation of hydrotalcites and also mixed oxides. The transesterification was carried out at different weight hour space velocity – WHSV (1, 2 and 3 h^{-1}) and different reaction temperatures (115, 150 and 200 °C), each parameter was tested for 32 h. Moreover, the stability of catalyst was tested by the determination of metals in reaction mixture, which is very often omitted in open literature. The ester yield increased (from 26 to 60 % for Mg-Al mixed oxides) with decreasing WHSV and with increasing reaction temperature (from 65 % to 97 % for Mg-Al mixed oxides). The Mg-Al mixed oxides were more active for all WHSV and temperatures 115 and 150 °C due to lower crystallite size and particularly higher concentration of active basic species (determined by TDP-CO_2). The relations between material properties and catalyst activity are described. In the case of reaction temperature 200 °C, the catalyst activity was almost the same (the ester yield 97%). The long time catalytic test (300 h) for verification of catalyst lifetime and stability was also carried out. The ester yield was 90 % for Mg-Al and 55 % for Mg-Fe for long catalyst tests, so stability of the catalysts was proven. Only insignificant leaching of metals was determined for all catalysts throughout reaction, i.e. the catalysts were stable.

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SDEWES2018.0159

Molybdenum Nitrides, Carbides, and Phosphides as Highly Efficient Catalysts for Hydrodeoxygenation of Biomass

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Abstract

Europe legislative requirements contain three major targets for the next three decades: reducing greenhouse gas emission, generating renewable energy and increasing energy efficiency. Biomass transformation to required biofuels is affording to reach these demands. Industrial production of hydrocarbons suitable for biodiesel already inquires revision of some technical aspects such as substitution of noble-based or sulphur containing catalysts. Hydrotreating of vegetable oils includes deoxygenation stage as the most important which adapts produced fuels for direct use in diesel engines. Hydrodeoxygenation (HDO) of stearic acid (SA) as a model reaction is commonly used to investigate chemical transformations of biomass when developing new catalytic systems. Transition metal nitrides, carbides, and phosphides exhibit properties similar to noble metals due to increasing the metal-metal bond distance by incorporation of corresponding ions into a MeOx framework.

In this study, bulk molybdenum-based materials were prepared by the temperature-programmed reduction method (H_2/N_2 or CH_4/N_2 flow at 700-900 °C) followed by passivation with oxygen. Influence of various precursors on phase composition and catalytic activity of produced samples was examined in HDO of SA under H_2 pressure (50 bar) in batch conditions using a Parr autoclave (360 °C, 700 RPM). Catalytic results and product distribution were correlated with physicochemical and textural properties analysed by XRD, N_2-adsorption, H_2-TPR, TEM, and SEM techniques and compared to traditional catalysts.

The presence of hexamethylenetetramine in the precursor mixture positively influenced the phase composition and ensured the synthesis of pure Mo_2N, Mo_2C, and MoP. The total degree of deoxygenation over the fresh catalysts decreased in the order $Mo_2C > Mo_2N > MoP$ where the carbide, characterized by the largest surface area, reached 91% deoxygenation at 98 % SA conversion after 4 h, however reusing the phosphide sample in the second catalytic cycle exhibited >99% at a total feedstock conversion.

The obtained results suggest a high potential of molybdenum-based systems as alternative catalysts for application in hydrodeoxygenation processes essential for biomass upgrading.

Acknowledgements:

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SDEWES2018.0345

Gasification Treatments of Poplar Biomass Produced in Contaminated Area Restored by Plant Assisted Bioremediation

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Abstract

Gasification represents a viable solution for the treatment of biomass aiming at producing a syngas with an overall conversion efficiency reaching the 75% level. Apart the syngas, the process produces solid residuals (ashes and unburned carbon-char) as well as heavy hydrocarbons (tars) that must be separated from the main gas flow. Here we present the outcomes of a gasification treatment conducted on poplar biomass samples collected from a multi contaminated area of Southern Italy restored by plant assisted bioremediation (PABR) aiming at reducing heavy metal (HM) and PCB contents in the contaminated soil. Pruning residues were collected from the poplar treated area located close to Taranto city. HM and PCB analyses were carried out to evaluate the overall content of these contaminants in the biomass. This preliminary evaluation is necessary for assessing the quality of the biomass and estimating the ensuing pollution in comparison with non-contaminated biomass. In fact, at the moment, the PABR residuals are classified by the Italian legislation as wastes and not as biomass usable for energy purposes when they are produced in contaminated areas. Our aim is to indicate the specific additional treatments possibly required for trapping HMs and PCBs in ashes, thus demonstrating that the PABR biomass gasification is not more pollutant than non-contaminated biomass.

The gasification process was carried out in a lab-scale gasifier system, designed at the Faculty of Civil and Industrial Engineering at Sapienza University of Rome. Moreover, we investigated the catalytic effect (and its related impact) associated to the presence of HMs in the biomass as well as the distribution of the HMs and PCBs among the ashes, filters and tars.

SDEWES2018.0480

Impact of Pretreatments Methods on Production of Bioethanol and Nanocrystalline Cellulose

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Abstract

Cellulose, the most abundant terrestrial biopolymer, has great potential for versatile applications. Due to two crystallinity regions of cellulose, dual applications could lead to optimal efficiencies for utilization. Due to the recalcitrant nature of lignocellulosic materials, various alkaline and acid pretreatment methods have been developed to recover mono sugar for fermentation. Simultaneous production of bioethanol and nanocrystalline cellulose from pretreated Formosan alder biomass was conducted in this study in two stages. Formosan alder biomass treated by unbleached kraft (UEK), acid steam explosion (SEP), bleached acid steam explosion (BSEP) were hydrolyzed by cellulase in the first step in this study. Filter paper and alpha-cellulose were also used for positive controls. Then bioethanol fermentation by E. coli Ko11 was conducted in the second step. Residual biomass was further recovered to produce nanocrystalline cellulose. After 96-hour enzyme hydrolysis, the highest sugar yields were 383.4, 329.84 mg glucose/ g biomass, for filter paper and UEK samples. Highest bioethanol fermentation yields were 4.18, 3.62 g bioethanol/ g biomass, for filter paper and UEK samples. During enzyme hydrolysis of biomass, crystallinity was increased for all biomass. Nanocrystalline cellulose yields were 68 and 73 % for filter paper and UEK samples. Nanocrystalline cellulose yields were 613.93 and 1583 nm for filter paper and UEK samples. Negative impact of lignin presence was still demonstrated and reflected in the particle length of final nanocrystalline cellulose. Further lignin removal is still required for satisfactory nanocrystalline cellulose production. Above results demonstrate that Formosan alder biomass could provide not only bioethanols but also nanocrystalline cellulose.

Advanced energy conversion systems

SDEWES2018.0028

Analytical Solution and Optimization for Energy Harvesting from Nonlinear Transverse Vibration of Rectangular Piezoelectric Plate

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Abstract

In this paper, a mathematical model for a Piezoelectric plate which is used for harvesting the energy from nonlinear transverse vibration has been presented. For this purpose, at first, nonlinear equation of motion of the PZT plate have been derived based on the Kirchhoff plate theory. Then, the equivalent electrical circuit of the structures is developed. These equations have been reduced to some ordinary deferential equations (ODE) using Airy stress function and Galerkin Method. Using Method of Multiple scales (MMS), an analytical solution has been done and a closed form relation for the output power of harvester has been obtained. To validate the obtained results from these relations, a FE Modeling using COMSOL Multiphysics has been made and a good agreement between FEM results and numerical solution of the mathematic model for displacement and voltage have been shown. After validation, to extract the maximum power, introducing analytical relation for the power as cost function, an optimization for extracting the best parameters of the harvester to obtain the maximum power has been done using Genetic Algorithm method. Also, the effect of various parameters of the structure such as dimension and thickness on the power have been investigated.

SDEWES2018.0074

Novel Heating Systems for LNG Regasification with Ranque-Hilsch Vortex Tube and Ejector to Re-Generate Ambient Air Heat Source

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Abstract

This paper proposed two novel systems to reduce or eliminate the energy consumption and pollution emission of the gas combustion in water-bath heater, when the ambient air vaporizers have a lower heat transfer coefficient for LNG regasification. Detail systems description had been presented and the corresponding mathematical model had been built. The key component is a Ranque-Hilsch vortex tube for the two systems (ejector also plays an important role in the secondary heating system) and heat can be extracted from the ambient air in the ambient air heat exchanger with the gas temperature drop down at the cold end of vortex tube. Preliminary quantitative analyzation was conducted for the operation of 10000 Nm^3/h flow rate at outlets of ambient air vaporizers, and the average temperature rise requirement ranges from 5-30 °C annually. The results shown that both systems can save large amount of energy from the water-bath heater, although the energy saving ratio decreases with the increasing temperature rise requirement. Huge energy consumption can be saved and zero pollution emission can be realized at the same time, which makes up the deficiency of the low efficiency of ambient air vaporizers for LNG regasification.

SDEWES2018.0107

Economic Leverage of Thermodynamic Hydrate Inhibitor Recovery from Raw Natural Gas with Supersonic Separator: Post-Combustion Capture of 43% of CO2 Emissions Preserving Offshore Gas Plant Profitability

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Abstract

Offshore oil and gas production is a major CO_2 emitter as gas processing is highly power intensive for conditioning and transporting natural gas (NG). In offshore rigs CO_2 emissions mainly come from gas-fired power generation. In order to make room for economically sustained post-combustion carbon capture, new more efficient NG processing is needed. Offshore NG fields requiring injection of thermodynamic hydrate inhibitor (THI) must have a THI recovery unit (THI-RU) for re-concentration of THI in the bottom water phase from the high-pressure separator (HPS) fed with incoming raw NG, while the HPS gas goes to NG conditioning for hydrocarbon dew point adjustment (HCDPA) and water dew point adjustment (WDPA) so as to make NG exportable. In conventional plants, WDPA and HCDPA are done by glycol absorption and Joule-Thomson expansion respectively. Moreover, the HPS gas carries some THI (e.g. methanol) that is lost in the processing. This work analyses a new process – SS-THI-Recovery – where HPS gas feeds a supersonic separator (SS) with injected water. As a result, SS ejects a cold two-phase condensate with almost all water, THI and C3+ hydrocarbons, discharging exportable NG with enough HCDPA and WDPA grades, while the condensate gives aqueous THI returned to the THI-RU and tradable LPG. Thus, SS-THI-Recovery not only avoids THI losses as well as exports NG and LPG, improving dramatically the gas plant profitability. It is shown that such leverage for methanol as THI can pay a post-combustion mono-ethanolamine (MEA) plant capturing about 43% of the gas plant CO_2 emissions, assuming 80MW of power generation. Both conventional gas plant and SS-THI-Recovery alternative (both coupled to respective THI-RUs and the latter also coupled to a post-combustion MEA plant) were simulated in HYSYS v8.8 with subsequent equipment design and economic analysis. Despite the higher capital investment of SS-THI-Recovery alternative, it has several advantages: (i) superior revenues due to higher production of better grade LPG; (ii) much lower THI make-up costs; and (iii) 43% lower carbon taxation costs. Even paying post-combustion costs, SS-THI-Recovery gave slightly higher net present value (23 years) than the conventional route. Hence, the higher efficiency of SS-THI-recovery makes it not only economic feasible, but also more environmentally adequate with cleaner NG and LPG productions.

SDEWES2018.0418

On the Production of Aluminum and Silicon by Electrolysis

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Abstract

Aluminum production by electrolysis of molten salt stems from the Hall-Heroult process. In this industrial process, second only to the chlor-alkali industry, aluminum is obtained by electrolysis of alumina dissolved in molten cryolite. The basic raw material is hydrated alumina Al_2O_3-H_2O with Al content of just 40% which is put into the cell's bath after intense pretreatment. The electrolyte consists of 2-6% aqueous solution of Al_2O_3, molten cryolite $3NaF$-AlF_3, and additives of calcium and aluminum trifluorides CaF_3 and AlF_3 and is kept at 940-980^oC which is much higher than the melting point of aluminum (660^oC). The density of molten aluminum is higher than that of electrolyte at this temperature, so it sinks to the bottom and is siphoned off periodically. The significant advantage of using this difference of densities is that molten Al is preserved from air oxidation, and there is no need in the inert atmosphere.

According to a Faraday law, the energy required for production of 1 kg of Al is defined as $W_{Al} = F{\cdot}V_c{\cdot}z/A{\cdot}\zeta$,where F is Faraday constant, V_c – voltage applied to the cell, z – valency of Al, A – atomic weight of Al, ζ – efficiency factor of electrolytic cell. By using the values z = 3, A=27.0, we obtain W_{Al} = 10.73 V_c/ζ MJ kg^{-1}. For a typical cell employed in modern industry V_c is roughly 4V and ζ=0.9; hence, the required energy is 47 MJ kg^{-1} . Required value of voltage includes namely voltage required for transformation of oxide alumina into aluminum (1.75 V) and also the overall voltage drop in the cell (roughly 1.5 V) consisting of voltage drops along the anode, the connectors, lining, etc.

As for the silicon production, upon entering z=4 and A=28.0 in the formula , we obtain W_{Si}=13,79V_c/ζ MJ kg^{-1}.

Using the same values V_c=4V and ζ=0.9, we find that W_{Si} exceeds W_{Al} by 23.5%. This increased level of energy consumption is due to high melting point of Si (1412 ^oC) which markedly exceeds that of aluminum.

Tajikistan, with the ready availability of significant hydropower resources, has good prospects to become a major Si producer like such already established ones as Norway and Iceland. The anticipated completion of the main utilities of Rogun hydropower plant gives meaning to development plans for silicon industry in parallel with the already running large-scale production of aluminum, not in the least because the country possesses large reserves of such high-purity silicon minerals as rock crystal and veined quartz. The solid experience of Tajik Aluminum Company workers, engineers, and scientists, obtained during more than 40 years of crude aluminum production, could be of great help in the development of Tajik silicon industry.

SDEWES2018.0481

Study of the Effect of Flame Top Confinement with Porous Ceramic Foams on the Emissions of a Domestic Pellet Boiler

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Abstract

Biomass domestic boilers are an important source of pollutant emissions. Due to the variability in the agricultural waste-based fuels, and the problems related to alkalinity of the ashes, biomass boilers need integrated and highly efficient emission control systems. Besides, following the progression of the European Council regarding the control and limitation of atmospheric pollutants, and given their proliferation and high worldwide impact, domestic boilers must improve their emission control systems in order to accomplish future new emissions regulations.

In this work an experimental study has been conducted to analyze the effect of confining the combustion flame on the NO_x, CO, and PM emissions of a domestic pellet boiler. A 21 kW commercial boiler was used for this purpose without any substantial modification on its original design. The objective of this preliminary study was to find potential benefits on the emission levels of a modern boiler with a very cheap and simple solution. A block of high porosity SiC foam was used as confinement element by placing it in the upper part of the flame, in the pathway of the combustion flue gases. Along with the concentrations of the above mentioned pollutants in the flue gases, the temperature in representative points of the boiler was measured testing the system in stable and controlled operating conditions.

By introducing this confinement element, a drastic reduction of the temperature levels in the combustion chamber was observed. As a consequence, a reduction in the NO_x emissions and an increase in the unburnt products (CO and PM) were measured. The observation of significant soot deposits on the tested foam samples shows the particles retention capacity of this material and its potential to be used as filter for these applications. The obtained preliminary results are promising considering the ease of implementation and low cost. This study is the first part of an on-going research work. In further stages of the project, actions will be taken to eliminate the negative effect of the temperature reduction, including modifications in the design of the boiler or in the position of the confining element.

SDEWES2018.0531

Techno-Economic Assessment of BECCS Systems in the Brazilian Sugarcane Sector

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Abstract

In order to maintain 2°C as the maximum increase in the global average temperature, worldwide emissions of CO_2 have to be significantly reduced. In the case of energy sector, in this scenario emissions from electricity generation shall be negative by the end of the century and only capturing CO_2 in bioelectricity systems this target would be reached. In this sense, fostering the so called BECCS technology – Bio-Energy systems with Carbon Capture and Storage – in sugarcane mills would be crucial, –contributing with low greenhouse gas (GHG) emissions in both the transport sector (with avoided emissions due to the displacement of fossil gasoline) and in the generation of electricity. The production of ethanol (via the fermentation of sugars) releases a pure stream of CO_2, which means no penalty for its separation in the CCS process. This is the most obvious option to capture CO_2 in sugarcane mills, and it is estimated that, considering current ethanol production of 28.5 million m^3, it would be possible to reduce CO_2 emissions by 27.7 million tonnes per year in Brazil. Carbon capture in sugarcane mills could at least double with the adoption of CCS technologies in cogeneration systems, in which residual biomass is burned - traditionally bagasse, and more recently, bagasse combined with straw. This paper presents a technical and economic assessment of BECCS systems in a typical Brazilian sugarcane mill, considering advanced steam cogeneration systems. The results are based on computational simulations of a modern power unit, burning both bagasse and straw. The post combustion capture technology based on amine was considered integrated to the mill and to the cogeneration system. A range of energy requirements and costs were taken from the literature, and different milling capacities and capturing rates were considered. Results show that CO_2 capture, both from fermentation and combustion, is technically feasible. Nevertheless, energy penalties are meaningful, with high impacts on surplus electricity. In the reference case, the cost of avoided CO_2 emissions was estimated at 62.4 €/t CO_2, and this can be reduced to 60.9 €/t CO_2 in case of more efficient technologies, or to 49 €/t CO_2 in case of larger plants.

Cogeneration and trigeneration

SDEWES2018.0044

Analysis of Micro-Combined Heat and Power Systems Coupled with Residential Buildings

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Abstract

The micro combined heat and power (µCHP) is a technology which produces simultaneously decentralized thermal and electrical energy at low power (electrical power lower than 50 kW_{el}). This technology recovers the “fatal heat” losses considered as “heat waste” produced in thermodynamics cycles for mechanic energy production. Micro-CHP technology offers significant benefits: reduced primary energy consumptions, reduced CO_2 emissions, avoidance of central plant and network construction. A wood pellet steam engine and a gas Stirling engine micro-CHP devices have been tested at the Climatherm laboratory of INSA Strasbourg in order to characterize their performances in steady and unsteady states. Two dynamic models based on these experimental investigations have been developed in order to predict their energy performance. These models have been implemented in the TRNSYS’s numerical environment where an optimization platform has been implemented. Thermal and electrical energy storage systems and energy management controller have been implemented in this platform which is used to optimize the coupling between buildings and the micro combined heat and power devices by considering energetic, economic and environmental criteria. This work presents the micro combined heat and power systems, the simulation platform, the energy storage systems and the control strategies possibilities. We also show how the thermal sensitivity of the French energetic mix correlates the economic, environmental and energetic performances of the micro combined heat and power systems.

SDEWES2018.0199

Modelling of Two Innovative Small-Scale Solar Organic Rankine Cycle Trigeneration Systems and Comparison of Their Thermodynamic Performance

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Abstract

In order to reduce the current fossil fuel energy consumption and meet the challenging climate goals set by the Paris Agreement, renewable energy technologies are of paramount importance. Among them, solar technologies are becoming more and more attractive thanks to their increasing performance and cost-competitiveness. Nowadays, one of the most promising application of solar thermal technologies is its combination with Organic Rankine Cycle (ORC) plants. Many recent studies have focused on this topic but very few of them have dealt with small scale solar Organic Rankine Cycle plants as trigeneration systems. In this paper two different small scale concentrated solar Organic Rankine Cycle units coupled with the same absorption chiller for trigeneration purposes have been investigated by means of a simulation analysis in TRNSYS. More precisely, the first system consists of a 146 m^2 Compound Parabolic Collector solar field, a diathermic oil storage tank and a 3.5 kWe ORC plant while the second of a 146 m^2 Linear Fresnel Reflectors solar field, a phase change material storage tank and a 2kWe ORC unit both coupled with a 17 kWc absorber. The first plant is similar to the real and experimental system designed and tested by some of the authors in the STS National research project, apart from the size of the solar field area, while the second is an extension of the prototype plant that is going to be built and tested under the European funded H2020 Innova MicroSolar project, led by Northumbria University.

The present work relies on the evaluation of the dynamic performance of the mentioned plants at two different Italian locations. In particular, the analysis has shown that the LFR-ORC plant is able to achieve higher electric energy production despite the lower size of the ORC.

SDEWES2018.0254

Analysis of Integration of Solar Organic Rankine Cycle for Domestic Combined Heat Power Generation

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Abstract

In 2016 the residential sector represented 25.4% of final energy consumption in the European Union. Currently in different countries of Europe, among them Spain, regulation imposes the installation of solar heating systems for new buildings. In many cases these facilities are underused along significant daily periods, especially during summer in warm regions. An interesting option to improve the use of the solar thermal systems is the integration with an Organic Rankine Cycles (ORC) to generate electricity. Thus, it would also be avoided overheating problems of solar panels since the excess of energy would be used for the production of electricity. The objective of the paper is to evaluate the technical and economic possibilities for the integration of solar thermal and ORC to conform a residential microCHP system able to cover a significant amount of the energy requirements of a standard house. Moreover, several strategies are analyzed to incorporate energy storage within the microCHP system. On this purpose, two different operation modes of the system are evaluated, isolated and integrated within the grid network. Then an economic analysis of the proposed integrated system is done for locations at the north and south of Spain, considering several potential scenarios of electricity and solar collector costs. The proposed microCHP system shows an interesting potential to increment the utilization factor of existing solar installations. Results from economic analysis show IRR values over 10% and positive NPV values.

SDEWES2018.0284

Improvement of a Cogeneration System in a Food Industry

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Abstract

In order to reduce the impact of heat intensive industrial process on environment, since 1974 the Council of the European Union started promoting the Cogeneration Heat and Power (CHP) concept. This strategy was carried forward in following years. The aim of these directive are to promote cogeneration systems and therefore to reduce the greenhouses gas emission, the fuel consumption and to improve energy efficiency. Cogeneration systems represent an interesting solution in order to reach these objectives.

The principal problem related to the use of CHP systems is the capacity to reach high efficiency suppling contemporary thermal and electric energy demand. Furthermore, the load profile usually is not regular increasing the difficulty to be covered from CHP systems. In order to solve these two criticises it is proposed a method for optimizing CHP systems size and management. These method aim to reach an energy saving of 10 % (at least) of primary energy, using a "parametrised cumulative curve" of total energy demand.

An energy audit of an industrial pasta factory has been carried out along the last two years. Then it has been chosen a natural gas fuelled cogeneration system, sized with the proposed method. This CHP plant currently covers a relevant fraction of the electric and high-temperature heat loads during peak hours, while it is switched off during off-peak hours due to the much lower electricity price. Heat content of exhaust gases is recovered by two cascaded gas-diathermic oil and diathermic oil-water heat exchangers; the superheated water obtained is then supplied to the pasta dryers. A detailed plant description, an energetic and economic analysis are provided, indicating margins for improvement of the current CHP system based on maximizing heat recovery. The existing plant only exploits heat recovery at high temperature (from exhaust gases), while a fraction of the thermal demand is associated with low temperature heat uses. Hence, a first hypothesis includes an additional low temperature heat recovery from the cooling jacket water and the lubrication oil circuits of the prime mover. As the above solution allows to achieve only minor benefits, from an economic viewpoint, a second and more comprehensive hypothesis was made, based on the use of a CHP gas turbine. Once sized the turbine to cover the peak heat load of the pasta factory, energetic and economic analyses revealed the convenience of this second scheme compared to the other existing lay-out.

SDEWES2018.0454

Investigating the Possibilities of Olive Oil Production Residues' Utilization for Combined Heat and Electricity Generation: a Case Study in the Province of Messinia, Greece

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Abstract

The importance of olive oil production for Greece and the environmental impacts of its organic residues have been the main incentives for composing the present paper.

The investigation of an alternative way of utilizing olive-cake in the province of Messinia, Peloponnese, is the aim of the paper. Currently, olive-cake is processed for producing pomace oil and pomace wood. Pomace wood is mainly exported. The alternative proposal is the use of pomace wood as fuel in a biomass combustion, co-generative unit. The unit will produce “green” electricity and distribute heat to a small town via a district heating network. The main research objectives are: (a) the basic dimensioning of the biomass unit, according to the pomace wood potential of Messinia and (b) the cost-benefit analysis of the unit, including Monte Carlo simulation and socioeconomic analysis.

The major research finding is that such an alternative plan for utilizing pomace wood at local level is a realistic choice. Supposing that local pomace wood industries provide the biomass unit with wood at the current wholesale prices, the investment proves to be viable. More specifically, the total cost of a 5 MW co-generative energy unit (including the district heating network) is about 6,500,000 euros. The unit proves to be feasible, even if it provides heat with 30% lower cost than diesel oil heat cost to the potential consumers. The produced heat is adequate for about 500 households, both for space heating and hot water production. The inclusion of environmental and social benefits in the analysis makes the investment even more attractive. It is noted that the dimensioning of the unit does not exhaust the pomace wood potential.

The research results show that the produced pomace wood in Messinia can be utilized at local level – instead of exporting it – for renewable heat and electricity generation, in a financially viable way. Taking into account that 20% of the Greek olive oil comes from Messinia, the present study is a representative example of how olive oil production in Greece could be sustainable and part of circular economy.

SDEWES2018.0533

Utilization of Cogeneration Heat in Hot and Humid Mediterranean Climates: Exergetic Change of the Game by Solar Cooling Versus Absorption Cooling

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Abstract

This paper investigates whether the cogeneration of cold and power is more energy and exergy rational and fuel efficient than cogeneration of power and heat. This investigation has been extended to several degrees of trigeneration. Three primary cases were considered, namely cold output only, heat output only, and trigeneration subjected to several system and equipment combinations, involving heat pumps, on-site electricity driven chillers, grid electricity driven chillers, organic Rankine (bottoming) cycle generators, and thermal storage. A novel PVT system was also investigated for solar trigeneration applications. Based on the split of heat into heat and cold with exergy rationality, two new models were developed in order to analyze these case studies, which showed that the most fuel-efficient option is simple cogeneration, if sustainable and sufficient demand for heat exists. Otherwise, trigeneration may be applied especially if a suitable thermal storage unit is added. In order to search such a practically next-best solution, a resort hotel in the Mediterranean coast of Antalya was considered with an optimized set of sea-water sourced heat pumps, absorption cooling machines, all of which are driven by natural-gas driven cogeneration units with thermal storage. Calculations based on EU/2004/8/EC Directive predicted only a 33% savings at peak-season design conditions. On the other hands, with the models being developed in this study, which consider exergy destructions and exergy differences between heat and cold generation based on the Second-Law of Thermodynamics, the predicted fuel saving is

62%. In order to establish a green alternative base, a new solar trigeneration system concept with PVT panels integrated with heat pipes and thermo-electric generators on building roofs and façades was developed and presented as a second case of a solar adobe house for climatic conditions of Sicily, showing that solar trigeneration for NZEXB applications in the Mediterranean is feasible.

Renewable for electricity generation

SDEWES2018.0150

Solar Electricity Generation in Hybrid Thermal Power Plants

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Abstract

The EU Directive on renewable sources, Directive 2009/28/EU, requires European countries to increase renewable energy uses until they reach 20% of gross final energy consumption. This target has been distributed among the member states which have put incentives on renewable energy uses and renewable electricity generation.

Among renewable sources, solar energy is one of the most interesting but it presents a key issue: it is a non-dispatchable renewable energy source. For this reason, when solar energy is used to produce electricity, concentrated solar thermal power plants are often integrated in conventional fossil power plants (hybrid power plants); in this case it is very important to distinguish the amount of electricity produced by this renewable source from the one produced by fossil source, since the two heat inputs can contribute to electricity production in different measure. It is possible to elaborate numerical models able to quantify performance of hybrid power plants and to allocate the total electricity for each energy source: for example, assuming a constant fuel consumption and adding solar heat, these numerical simulations allow evaluating the extra electricity generated, that is really the electricity from solar energy. However, such an evaluation is impossible during power plant operation.

This paper presents a simple, but effective, methodology able to distinguish electricity generation of each energy source during hybrid power plants operation: it is necessary to know (by measures) only heat input from fuel and solar energy, initial and final temperatures of working fluid during heat addition and rejection, and the factor of internal losses. This last parameter is very important and this paper not only demonstrates that it doesn't depend on solar energy share but it also proposes its evaluation. Finally the paper compares results of this methodology with those of numerical models here elaborated showing their perfect correspondence in solar electricity evaluation.

SDEWES2018.0203

Thermochemical Energy Storage of Solar PV to Enhance Dispatchability and Large Scale Commercial Expansion

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Abstract

Solar photovoltaics (PV) plants are today a competitive alternative to power plants based on fossil fuels. Cost reduction in PV modules, scalability (from kW to MW) and ease of installation of PV plants are enabling a rapid expansion of the technology throughout the world. Nevertheless, PV dispatchability still remains as the major challenge to be overcome due to intrinsic variability of solar energy. Most of the current PV facilities lack energy storage while those with storage systems rely on expensive batteries. Batteries are based on elements such as nickel, lithium or cadmium whose scarcity hinder the sustainability of batteries for storing energy in the large scale. This manuscript presents a novel concept to integrate thermochemical energy storage in PV plants. Furthermore, the concept is also directly adaptable to wind power plants in order to store surplus energy. In particular, this paper analyses the suitability of the Calcium-Looping (CaL) process as thermochemical energy storage system applied to large scale PV facilities. The PV-CaL integration works as follows: a part of power produced in the PV plant provides electricity to the grid while the rest is used to supply heat to carry out the calcination of $CaCO_3$. After calcination, the products of the reaction (CaO and CO_2) are stored separately. When power production is required, the stored products are brought together in a carbonation reactor wherein the exothermic reaction releases energy for power production. The overall system is simulated in order to estimate the process behaviour and results show that storage efficiencies of ~40% can be achieved. Moreover, an economic analysis is developed to compare the proposed system with batteries. Due to the low price of natural CaO precursors such as limestone and the longer lifetime of equipment than batteries, the CaL process can be considered as a promising alternative to increase dispatchability in PV plants. Moreover, limestone is abundant and non-toxic, which is an essential requirement for the storage of energy in massive amounts.

SDEWES2018.0303

Theoretical Possibilities of Using Photovoltaic and Wind Turbine Technologies in Synergy

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Abstract

The electricity generation based on wind and solar radiation is well established as the primary sources of renewable energy. However, their efficiency and the amount of energy obtained is highly dependent on conditions in which these solutions are used. Energy generation by wind turbines are related to wind speed, while by PV panels mostly on its location on the globe. Currently the solutions which would effectively combine both technologies are not very common, but it seems to be a very promising solution. The design of such a device should be supported by precise analysis regarding the possibility of its use in specific locations. In the manuscript cost-effectiveness analysis of implementation of synergistic solutions combining wind and solar technologies was described. It was delivered by evaluating parameters affecting the operation of devices and its characteristic in several selected zones of the World. It is followed by a series of theoretical calculations showing the total of energy yields from different scenarios. As a result of the research given in the manuscript, it was possible to determine that the use of wind turbine technology and photovoltaic cells in synergy could be more beneficial than using standalone systems in many cases. The optimization of installation location in terms of its efficiency for standalone and synergistic scenarios is described in the manuscript as well.

SDEWES2018.0425

A Novel Hybrid Approach Base on Fuzzy Multi- Criteria Decision-Making Tools for Assessing Sustainable Alternatives of Power Generation in San Andrés Island

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Abstract

San Andrés is the largest of the island group in the Department of the Archipelago of San Andrés, Providencia and Santa Catalina of Colombia. San Andrés is located in the Caribbean Sea, about 750 km northwest of the coast of Colombia. The island is 12.5 km in length and 3 km in width. It has an area of 26 km^2 and the island's last reported population is 75000 people. To supply the electricity to the island have been established solutions with diesel generation, which are not sustainable in the long term, since an economical and environmental point of view.

Therefore, with the aim of planning a sustainable energetic future for supplying the electricity demand in the island in this work is proposed a novel hybrid approach based on fuzzy multi-criteria decision-making tools for assessing sustainable alternatives of power generation, through social, technological, environmental, and economic criteria.

In the first stage were established the energy resources (solar, wind, water and agricultural residual biomass potential) trough geographic information systems.

In the next stage a fuzzy multiobjective mixed-integer linear model was proposed for archiving the set of optimal combinations (Pareto front or alternatives), between solar photovoltaic, wind turbines, small hydro, biomass gasification, grid extension, and diesel plants to supply the expected energy demand. Therefore, the total present value and the total CO2 emissions of the power system were minimising taking into account design, operational, and efficiency constraints.

The CO_2 emissions and the total present value of the Pareto front, together with qualitative social, technological, and environmental criteria assessed trough expert's opinions were used as inputs in the next phase, in which was proposed a second novel model base on fuzzy logic for classifying each of the Pareto alternatives and selecting the most sustainable.

Finally, a real case study concerning San Andres Island energy planning system demonstrate the applicability of the proposed approach.

The results indicate for all the alternatives that the generation of energy from the current diesel capacity prevails, due to these plants have long-life cycle; give security for the system; and the implementation of new capacities cause additional land use, and growth in investment and operating costs. Consequently, the fuel saving between the alternative that favours the minimization of the total present value and the one that favours the minimization of CO_2 emissions is only of 7.09%, reaching maximum percentages of participation with solar photovoltaic and wind turbines of 3% and 4% respectively.

SDEWES2018.0435

Wind/PV/hydro-Pumping System for Shaving Electrical Peak Demand

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Abstract

A simulation tool for the operation of a hybrid PV/Wind plant coupled with a hydro-pumping storage (HPS) was built and used for simulating the behavior of such a system among an energy mix constituted by fuel oil generators and electrical cables in an insular electrical network (Corsica island). The modelling of each subsystem uses efficiency depending on the operation mode and meteorological conditions at an hourly time step. 4 reversible pumps working in parallel are used; thus, an optimized operation for the 4 pumps was developed, minimizing the electrical power used for pumping and maximizing the produced electricity power in turbine mode. This tool can be easily transposed to several cases differentiated by the operation strategy and the energy situation. The operation strategy of the hybrid system took into account other all the energy mix with imported electricity and fossil fuel power generators. The objective of the studied hybrid system was to shave the peak energy load. The covered peak demand can reach 80% in an annual basis. Some threshold values for the peak power of PV and WE plants appeared but they are more visible for the WE plant being able to produce also during the night and having a higher influence on the lost renewable energy. Some configurations were highlighted because their energy performances were good.

SDEWES2018.0542

Research on the Influence of Support Structure on Performance of Full-Scale Tidal Current Turbine

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Abstract

The presence of support structure may affect the performance of rotor's blades when the turbine is in operation. Taking the 50kW horizontal-axis tidal turbine with variable pitch system as the research object, the full-scale tidal turbine under different working conditions was simulated by Code_Saturne (CFD solver), and the influence of support structure on the performance of tidal turbine was studied. The numerical results showed that the support structure has less influence on the turbine under forward inflow conditions when the turbine is operating at a flow rate of 1.5m/s. However, the support structure has severe impacts on the turbine under reverse inflow conditions. When the single blade is in the wake of the support structure, the decrease of its axial and lift force is 22.4% and 91%, respectively; the total axial force of the rotor fluctuates by approximately 7%, and power of the turbine decreases by approximately 31%. This paper also provided a research method for the actual performance prediction of full-scale tidal current turbine, so as to provide a basis for the optimization of the design stage.

Water and materials treatment

SDEWES2018.0105

Removal of Mn and as from Drinking Water by Red Mud and Pyrolusite

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Abstract

Owing to a limited economic capability, which limits the access to advanced technologies, many developing countries are still facing with the challenge of reducing human exposure to heavy metals, which is primarily due to water consumption. In fact, as a consequence of both natural processes and anthropogenic activities, poorly treated domestic, industrial, and agricultural wastewater containing high concentrations of metals are released into the environment.

In wastewater treatment technology, adsorption is sometime preferred to other approaches because of its high efficiency, easy handling, availability of different substrates and cost effectiveness. Besides, there has recently been an increasing emphasis on using low-cost adsorbents (generally solid wastes) as an attractive and promising option for the treatment of polluted water, with a double benefit for the environment.

In this paper, the use of red mud and pyrolusite has been investigated for the removal of As and Mn from drinking water. Pyrolusite is the mineral form of MnO_2, a residual solid by-product in manganese hydrometallurgy, while red mud is a waste product, composed mainly of iron oxide, which is generated in the industrial production of alumina (Bayer process). Adsorption equilibrium data have been examined through the application of several linear and non-linear models at constant temperature (isotherms) for one or both contaminants. Batch and breakthrough tests have been exploited to clarify the effects of pH, initial metal ion concentration and temperature on the adsorption performance, and identify the best conditions for the treatment and the potential of the adsorbent materials.

SDEWES2018.0181

Copper Sortion Onto Dolomite in a Fixed Bed Tubular Reactor

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Abstract

The study of the removal of heavy metals in water has acquired great importance because these species accumulate in living organisms and can not be biodegraded, causing several diseases when they exceed the established limits. Copper is a widely used metal and there are many potential sources of contamination. It can be found in the aqueous waste streams of many industries such as electronics, veneers, mining, paper and wood production. Sorption is an effective method for the removal of heavy metals from aqueous solutions, the main disadvantage is the high cost of the adsorbent material. However, the use of abundant natural materials such as dolomite, offer good returns and environmentally friendly technologies. The objective of this study was to test the performance of a fixed bed continuous reactor filled with dolomite, taking different operational parameters. For the preparation of the working solutions $CuCl_2$ was used. To detect the amount of copper in the solution, a single-beam spectrophotometer was used. The system in continuous regime consisted of a cylindrical column of stainless steel of 1.5 cm of diameter and 10 cm of height, stuffed with dolomite with particle size between 0.4 and 0.5 mm, with bronze fittings on its ends and adapters that hold the tissue filter necessary to retain the filling inside the reactor. The fluid dynamics tests were carried out in the same continuous reactor system, using 0.2-0.4 mm diameter glass spheres as filler, under the same operating conditions as sorption. By means of these fluid dynamics tests it was possible to determine that the axial dispersion module is very close to zero, so that the flow in the reactor can be considered to tend to the piston flow. The results of the experiences with dolomite show that there is a direct proportionality between the concentration of income and the retention of the pollutant, while as the flow of income increases, the yield of sorption decreases. It was determined that the calculated sorption capacity is similar to the capacity obtained experimentally in batch systems. The results clearly indicate that the rupture curves under the experimental conditions employed were well described by the Thomas model.

SDEWES2018.0580

Electrocatalytic Properties of Carbon Nanotube Filters with Metal Doping

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Abstract

The complex process of electrochemical oxidation and membrane are emerging recently for water treatment technology. This process is a multifunctional device capable of simultaneously filtering, adsorbing, decomposing / removing contaminants. Generally, most of the electrochemical filters are based on porous carbon-based materials (for example, graphite, carbon nanotube, etc.). We fabricated CNT filters loaded with antimony (Sb)-doped tin oxide(Sb-SnO_2; SS) and bismuth- and antimony-codoped tin oxide (Bi, Sb-SnO_2; BSS) particles via electrosorption at 2 V for 1 h and examined the electrocatalytic activity and performance of multi-walled carbon nanotube (CNT) filters for water treatment in a sodium sulfate electrolyte(25Mm). The as-synthesized CNT filters were composed of 50–60-nm-thick tubular carbons, whereas SS-CNT and BSS-CNT filters were slightly thicker and bumpy due to the coating of metal(Sb, Bi) particles ~50 nm in size. SS-CNT and BSS-CNT indicated a positive shift in the onset potential. CNT filters indicated a similar adsorption capacity (5–8%) for 0.5 mM phenol solution, whereas coatings of SS and BSS enhanced the phenol oxidation rate by ~1.5 and 2.1 times, respectively. In particular, the TOC (total organic carbon) removal and mineralization efficiency of the BSS-CNT filters were twice as much as the other electrode.

SDEWES2018.0597

Thermodynamic Estimation of Ash Melting Behavior and Viscosity for Coal Gasifier

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Abstract

According to the Paris Agreement in 2016, Japan has set a goal of 26% reducing greenhouse gas emissions by 2030 compared with the level in 2013. Integrated gasification combined cycle (IGCC) is showing considerable promise for reducing CO_2 emission as an electric power generation system. It is known that in IGCC slagging gasifiers, the slags (melting ash) should be 'fluid' enough to be tapped. One of the major parameters in the design and operation of the coal gasifier is the knowledge of the melting behaviour of the coal mineral; therefore, estimation of the ash melting temperature and slag viscosity is important to choose coal types.

Thermodynamic estimation of ash melting behaviour was carried out to evaluate 4 different coals and there blended coals using the Factsage software. Factsage is one of the largest fully integrated database computing systems in chemical thermodynamics. Input dataset and selection of thermodynamics database for Factsage modelling was carefully established for estimation of ash melting behaviour. The ratio of slag as a function of temperature was obtained the thermodynamic calculation for various coals. On the other hand, slag viscosity at a temperature was calculated by "modified Urbain model" which was developed by Kondratiev and Jak (2001).

To determine boundary conditions for choosing coals, calculated ash melting temperatures and its viscosity were compared with actual ash melting performance which was obtained by ash fluid experiments. In the ash fluid experiments, variation in the ratio of fluid slag at a temperature ranged from 1100 °C to 1600 °C was measured. The boundary condition for choosing coal was found that the ash melting temperature at the slag ratio of 80% is below 1250 °C, and the slag viscosity is below 30,000 Pa s at the ash melting temperature.

SDEWES2018.0630

A Study on CO2 Hydrate Formation Kinetics in Saline Water in the Presence of Low Concentrations of CH4

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Abstract

Gas hydrate formation has numerous potential applications in the fields of water desalination, gas and energy storage and safe transportation (e.g. Methane storage and transportation), gas capture, separation and substitution (e.g. GHG Capture, CO_2 separation from flue gases and extraction of methane from methane hydrates by CO_2 substitution). For its ability of selectively separating gases depending upon thermodynamic conditions and desalinating water, hydrate formation achieved a huge research attention. For the hydrate formation to occur, the availability of interaction between water and the guest gas are essential. Because of higher salt and water interactions in the presence of salt or less hydrate former and water interactions in the presence of a gaseous pollutant, studies express a concern of lowered rates and yields of hydrate formation with the addition of salts and the impurities in the guest gas. In the process of developing gas-hydrate formation to serve multiple purposes, in this study, CO_2 hydrate formation experiments were conducted in the presence of another hydrate forming gas, CH_4 at low concentrations in saline water with sea-water configuration. These experiments were conducted in both batch reactor and stirred tank reactor in the presence of Sodium Dodecyl Sulphate (SDS) as the kinetic additive at 3.5MPa and 1°C, under isobaric and isothermal conditions. Gas loading has been taken as the detection criterion for hydrate formation. It was observed that overall gas loading has been hindered by over 70% and by the addition of salts at the end of 2 days of the experimentation. Addition of 5mol% of CH_4 showed a further reduction of approximately 30% of gas loading in the batch reactor without stirring. However, the addition of 100ppm of SDS has observed to have improved the gas loading by recovering this loss by 34.3% of the loss observed in volumetric gas loading through the addition of salts and CH_4. The introduction of stirring improved the gas loading by recovering 64.53% of loss through the addition of salts and CH_4, by the end of 34 hours.

SDEWES2018.0631

Agricultural Nitrogen Balance Mapping in EU Based on Profit-Maximizing Assumption and Lucas Land Cover Survey Database

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Abstract

Eutrophisation of surface waters and gaseous nitrogen emissions are partly side effect of using nitrogen fertilizers. Sustainable growth of agriculture production giving base for food security of growing populations is one of the biggest challenges according to fact that nitrogen use efficiency of intensive farming crops is low. There is a need for simple no high data demanding method for comparing agricultural nitrogen loads from common crops and spatial assessment of environmental pressures on surface waters. The typical method is comparing nitrogen flows on farm level using data about crop yields and used fertilizers amounts. Such calculation is simple but unfortunately there no exist database collecting data about fertilizer use for EU with spatial resolution better than whole NUTS2 regions. Using common assumption that farmers are profit-maximizers and simple one parameter yield function dependent on nitrogen fertilization is possible to calculate corresponding optimal fertilization and yield levels. Relation between them is linear and depends on ratio of fertilizer to yield price. This result can be used to assessment of nitrogen balance by using only data about shares of crops in each localization and level of yields in region. Data about yields are available on the NUTS2 level in EUROSTAT database. Spatial data about cultivated crop are collected every third year in points on net with 2 km cell for whole EU in LUCAS survey. According to presented method a continuous map of nitrogen balance for EU was prepared and compared with maps generated by other approaches.

Modelling for pollution avoidance and energy efficiency

SDEWES2018.0167

A Clean Ultrasound-Assisted Extraction of Phenolic Compounds from Black Locust Flowers

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Abstract

Black locust flower (Robiniae pseudoacaciae flos) contains the various bioactive compounds with expressed pharmacological activities. These activities could be described to the presence of phenolic compounds. Due to this reason, the aim of this paper was to model and optimize the ultrasound-assisted extraction of polyphenols from black locust flowers using response surface methodology. The effects of three factors, the ethanol concentration (33-67%), extraction temperature (33-67 °C) and sonication time (17-33 min) on the total polyphenol content were investigated according to the central composite design. The liquid-to-solid ratio had the constant value of 20 $cm^3 \cdot g^{-1}$ during all experimental runs. The optimal conditions were determined to be 59 °C with 60% ethanol and sonication time of 30 min. The extract obtained under these conditions had the total polyphenol content of 3.12 g_{GAE}/100 g dry plant material, while the regression model predicted 3.17 g_{GAE}/100 g dry plant material. The developed UAE procedure was presented as the method of choice for extraction of phenolic compounds due to the short extraction time and low extraction temperature. The obtained ethanol extract enriched with polyphenols could be applied in the pharmaceutical and food industries.

SDEWES2018.0174

Integrating Industrial Waste Heat Recovery into Sustainable Smart Energy Systems

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Abstract

In order to achieve the ambitious objectives set by the European Union for the climate and energy goals, a transition towards a future sustainable energy supply is needed. The integration of the huge potential for industrial waste heat recovery into Smart Energy System (SES) represents a main opportunity to accomplish these goals.

To successfully implement this strategy, the adoption of a system approach is required, since all the several stakeholders' conflicting objectives should be considered. To address this challenge, in this paper an evolutionary multi-objective optimization model is developed to perform a sustainability evaluation of a SES involving an industrial facility as the waste heat source and the neighborhood with different characteristics and activities (residential, commercial, and institutional) as potential users by a district heating network, in the typical European city brown field context.

The model has been applied to an Italian case study, analysing heat recovery from a steel casting facility to satisfy the heating needs of the southern part of Udine Municipality through the realization of a district heating (DH) network. Different DH layout scenarios have been analysed, to consider the connection of the main current and future city areas and different clients.

Energy system modelling has been implemented in MATLAB®, while the genetic multi-objective optimization has been performed by modeFRONTIER®, which allows to mark the Pareto front of solutions and the Multi Criteria Decision Making (MCDM) post processing analysis.

Results show that the developed model allows to properly select the DH network set of users and system layout to fully exploit the available waste energy, in particular how involving a large and heterogeneous basin of clients leads to remarkable economic and environmental performances. Design configurations such as the best compromise for thermal energy storage capacity are also provided. Moreover, the multi-objective model enables the analysis of the trade-off between the stakeholders' different perspectives, allowing to identify possible win-win solutions for both the industrial sector and the citizenship

SDEWES2018.0179

Data Fusion Analysis Applied to Different Climate Change Models: an Application to the Building Sector

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Abstract

The paper aims to achieve the modelling of climate change effects on heating and cooling in the building sector, through the use of the available Intergovernmental Panel on Climate Change forecasted data. Data from several different climate models will be fused with regards to mean air temperature and horizontal solar radiation. Several climatic models data were analyzed ranging from January 2006 to December 2100. Rather than considering each model in isolation, we propose different data fusion approaches for providing the input data for the morphing method of an existing weather data file, aiming to the simulation of the future energy use for heating and cooling of a reference building. By comparing the climatic models with the actual data collected in the Era-Interim dataset, we observed that no model is able to simultaneously minimize the prediction errors on all the parameters relevant for energy consumption prediction.

Two different data fusion approaches were tested: a classical solution, based on a regularized linear regression model, devised to minimize the mean squared error of the time series given by the prediction vectors provided by each model; a solution based on the preliminary extraction of trend data provided by each model, before performing the model combination.

Since climate data are affected by statistical random fluctuations and seasonal behaviours, it is not always true that the model minimizing the prediction errors on a limited reference time interval is capturing a more accurate representation of the climate change. We propose a solution for decomposing the model data into trend behaviours, seasonal components and random fluctuations, thus enabling a model composition based on trend behaviours only.

Both the fusion approaches improve the performance of each combined model e.g. for the Air Temperature time series, the composed models provide a coefficient of determination R^2 equal to 0.89 in the case of mean squared errors, and a coefficient of determination R^2 equal to -2.71 in the case of trend fitting, whereas all models tested have R^2 lower than -3.85. However, minimization of squared errors can lead to surprising results: the mean squared model significantly overestimates the predictions on cooling energy use for 2090 in comparison to the combined models (up to 20% higher on a yearly base) , while the trend fitting approach provides results in the ranges of the ones provided by each model in isolation.

SDEWES2018.0399

Relationship Between Particle Size Distribution and Water-Soluble Ions in Industrial City of Ostrava, Czech Republic

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Abstract

The particle size distribution of particulate matter (PM) and concentrations of water-soluble ions were observed in airborne aerosol in the city Ostrava (the Czech Republic, Moravian-Silesian Region) during winter 2016. The Ostrava area ranks among the most polluted areas not only within the Czech Republic, but also in Europe. The water-soluble ions: sulphates $(SO_4)^{2-}$, nitrates $(NO_3)^-$, ammonium ions $(NH_4)^+$, chlorides $(Cl)^-$, magnesium $(Mg)^{2+}$, calcium $(Ca)^{2+}$, potassium $(K)^+$, sodium $(Na)^+$ and phosphates $(PO_4)^{3-}$ were studied in different grain size classes of particulate matter (0.0175 - 0.156, 0.156 - 0.258, 0.258 - 0.384, 0.384 - 0.606, 0.606 - 0.952, 0.952 - 2.48, and 2.48 - 9.93 µm) collected by an electrical low pressure impactor ELPI+. The average percentage of all monitored inorganic water-soluble ions in PM_{10} reached 56.0 ± 6.8%. The water-soluble ions as $(SO_4)^{2-}$, $(NO_3)^-$ and $(NH_4)^+$ were maximally accumulated in particles below 0.952 µm, and distributions of these water-soluble ions were significantly influenced by temperature and in particles between 0.606 and 0.952 µm, andalso by relative humidity.

SDEWES2018.0603

Optimisation of Axial Turbine for a Small Scale Waste Heat Recovery ORC System

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Abstract

Efficiency is one of the most important feature of the power systems as it greatly influences the economic balance. The efficiency can be improved in many ways. One of them is to optimize the individual components of a power plant. In most ORC systems the power is created in a turbine and these systems can benefit from effective turbine optimisation methods.

The possibility of improving the efficiency in ORC axial turbine has been investigated in an iterative process using a optimisation algorithms. Values of the maximised objective function, that is isentropic efficiency are found from 3D RANS computation of the flowpath geometry which was changing during the optimisation process. To secure the global flow conditions, the constraints have been imposed on the mass flow rate. Among the optimised parameters are stator design parameters, rotor twist angles, rotor sweep and lean, both straight and compound, meridional channel shape.

The optimisation gives new 3D stage designs with increased efficiency comparing to the original design due to reduction of secondary flow and boundary layer losses. Results highlight the potential of the optimisation technique to improve Organic Rankine Cycle performance.

SDEWES2018.0606

ICT Time-Series Monitoring Data Modeling to Estimate Electricity Consumption by Markov Switching Model for Connecting Treatment Process Operation; Case Study of a Wastewater Treatment Plant in Fukushima

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Abstract

The Great East Japan earthquake caused a major damage to many of public infrastructures including Wastewater treatment plants (WWTP) in Fukushima prefecture. Following the nuclear disaster, which lead to shortage of energy, government of Japan enacted new policy measures to redefine its energy mix. In 2015, Japan ratified the Paris accord and has set a national greenhouse gas reduction goal of 26 percent below 2013 levels by 2030.

To meet this requirement, Japan needs to restructure its current electricity consumption by identifying the optimal demand of electricity by some of sector likely to Sewage systems, especially WWTP. As a method of reducing the power consumption, operational controls likely to demand response are proposed. However, because WWTP main purpose is wastewater treatment, it is not possible to ignore water quality of effluent. So, there is a necessity to promote energy saving by performing necessary water treatment for water environment conservation.

In this study, we obtained the energy demand of WWTP, in Fukushima Prefecture, Japan, based on the data obtained using ICT monitoring systems. Using the data, we further predict electricity demand for each process of WWTP using Markov-Switching model; this model is one of a time-series analysis method what could be estimated state variables considered to treatment process. operation.

As a result, (1) we obtained hourly energy consumption data of each process on target WWTP, (2) we could develop time-series electricity consumption prediction models with high accuracy in the observation period, (3) we estimated each time probability of state variables; these variables could be used for prediction of each time operation.

In addition, we analyzed water effluent and operational data by operation report of target WWTP, and we considered to possibility of linking between WWTP process situation and estimated state variables.

Energy Systems Analysis

SDEWES2018.0134

CO2 Rich Natural Gas Offshore Processing with Supersonic Separator: CO2 Capture, Energy and Economic Assessments

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Abstract

Supersonic separation (SS) is an emerging technology for natural gas (NG) offshore processing. There are few works on correct SS thermodynamic modeling and simulation for CO_2 rich (>40%mol) NG conditioning steps such as Water Dew-Point Adjustment (WDPA), Hydrocarbon Dew-Point Adjustment (HCDPA) and CO_2 removal. In this work, SS is investigated via HYSYS 8.8 process simulation for WDPA, HCDPA and CO_2 removal for conditioning CO_2 rich raw NG. These applications are compared in terms of technical, energy and economic performances with conventional glycol absorption WDPA, Joule-Thomson Expansion HCDPA and Membrane Permeation (MP) CO_2 removal. The scenario corresponds to an offshore platform treating 45%mol CO_2 raw NG to produce lean NG with maximum %mol CO_2 of ≈20%mol suitable to gas-fired power generation and a CO_2 rich fluid that is compressed and injected for Enhanced Oil Recovery (EOR). Besides the conventional three-steps NG processing above-mentioned (so-called Case 1), two other processing alternatives are considered: (i) SS for WDPA/HCDPA and MP CO_2 removal (Case 2), and (ii) SS for WDPA/HCDPA and SS for CO_2 removal (Case 3). In HYSYS simulations MP and SS are modeled via Unit Operation Extensions MP-UOE and SS-UOE developed ad hoc in a previous work. Technical, energy and economic assessments are performed for comparison of Case 1, Case 2 and Case 3. Results show that replacing conventional WDPA+HCDPA by SS reduces power demand relatively to Case 1 by 7.8% while maintaining positive Net Present Value (NPV). Moreover, SS CO_2 removal also outperformed conventional MP CO_2 removal, mainly due to SS production of CO_2 rich EOR stream at high-pressure, entailing much less compression power for EOR than the low-pressure CO_2 rich MP permeate. Besides the environmental gain of lowest CO_2 emission, the lowest power consumption of SS-SS Case 3 (-20.5%) leads to best economic results: lowest cost of manufacturing and lowest compressor capital investment. Thus, Case 3 with two serial SS's for both WDPA/HCDPA and CO_2 removal is the overall best solution, with highest NPV after 20 years of operation (+860MMUSD).

SDEWES2018.0191

Comparison of Transcritical CO2 and Conventional Refrigerant Heat Pump Water Heaters for Domestic Applications

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Abstract

Introduction and Objectives

Transcritical CO_2-based heat pump water heaters (HPWH) are experiencing an increase of popularity due to growing environmental concerns. Most current applications use high global warming potential (GWP) refrigerants, and the replacement of these devices by others based on CO_2 may be explored as a possibility for a better environmental protection.

The CO_2-based HPWH cycle is transcritical above 32ºC, operating at pressures significantly higher than conventional subcritical cycles. In addition to its environmental advantages, the transcritical operation of the cycle provides a comparable or even higher COP values compered with the conventional ones for a high temperature lift at the side of the gascooler (about 30-40 ºC) and a low temperature of the water that needs to be heated. Nevertheless, also some disadvantages of the CO_2 HPWH have to be taken into account to decide the convenience of use for a particular application, as the increase of pressure above 100 bar.

This work provides a comparison of the performance of a R410A-based HPWH (conventional refrigerant) and a transcritical CO_2-based HPWH (TC-HPWH), exploring the possibility of the use of each of them for domestic hot water generation in an integrated system, where the evaporator temperatures are higher than the usual.

Methodology

For the analysis of the TC-HPWH cycle, a thermodynamic model to reproduce the behaviour of the Sanyo EcoCute SHP-C45DEN heat pump has been developed. The governing thermodynamic parameters and main assumptions have been tuned to fit the experimental data provided by prior studies. After validation of the model, the performance of the device has been extrapolated for the working conditions of the particular application under study.

For the R410A-based HPWH an experimental setup has been implemented. A Daikin EKHHP300AA2V3 heat pump has been instrumented and a series of experiments has been carried out across the desired range of evaporator temperatures. The data have been processed in order to obtain a model of the behaviour.

Main results and conclusions

Transcritical CO_2-based heat pump water heaters have an evident environmental potential, allowing for an application of CO_2 for widespread use. Apart from that, they have certain technological advantages such as lower limit-of-operation temperatures and certain drawbacks such as the high pressures involved. In terms of performance, they show comparable results.

On the other hand, R410A heat pumps are a consolidated technology, and a significant improvement in their performance can be observed for the range of evaporator temperatures considered in our application in comparison to the usual.

SDEWES2018.0276

Thermo-Economic Optimization of a Solar System for Sewage Sludge Drying

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Abstract

The main problems faced by wastewater treatment plants are high electric energy consumption and disposal of by-products, such as sewage sludge. For this reason, a hybrid system for electric energy supply and drying of sewage sludge is proposed. The layout presented is based on the integration of two renewable energy sources: biogas from anaerobic digestion of sludge is used to fuel a Combined Heat and Power system and solar energy is exploited through a parabolic trough collector field. The case study consists of a real wastewater treatment plant, in Campania region, Southern Italy. The system is designed to supply electricity to the plant and to dry the sludge produced up to 5-10% of final water content.

A detailed sensitivity analysis is performed, in order to evaluate the system performance as a function of different climatic conditions and main design parameters. The effect of solar field area and engine size are taken into account. Through this analysis, optimal design of the system is defined. The present work is based on a previous paper where the dynamic operation of the system and the energy and economic analysis for a base case study are performed.

The analysis of main results demonstrates that integration of different renewable energy sources is fundamental to improve sustainability of wastewater treatment plants, reducing the use of fossil fuels. Though a Primary Energy Saving is achieved compared to the existing plant. Concerning economic profitability, the system appears to be convenient. The use of a Combined Heat and Power system is found to be very cost-effective in wastewater treatment plants due to simultaneous demand of thermal and electrical energy. The best economic performance of the system is achieved for a CHP unit capacity of 2170 kW.

SDEWES2018.0324

Integration Ev Vehicle and Net-Zero-Energy-Building

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Abstract

The aim of this work is the analysis of the energy, environmental and economic performance of Building Integrated flat-plate Photovoltaic and Thermal (BIPVT) collectors for residential application coupled to an electric energy storage system and an electric vehicle.

The adopted BIPVT collectors simultaneously produce heat and electricity. The heat is used for space heating and domestic hot water purposes. The electricity is used to supply the electric devices of the building and the electric vehicle (EV), whereas the excess is stored into the energy storage system, in order to enhance the independency of the system from the public grid. The energy storage systems of the building and EV consist of lead-acid and lithium batteries[F1] , respectively.

In addition, in this work, particular attention is paid to the hourly electric load of the electric vehicle, carefully evaluated, as well as the electrical load of the building. In particular, in order to simulate an electric load as realistic as possible, each floor of the simulated 3 floors-building has a different number of users and a different occupancy schedule.

The investigated plant is designed to achieve a grid independent system, by saving a significant amount of energy and avoiding the use of the energy produced by the conventional fossil fuels. This also determines a noteworthy reduction of the CO_2 and other pollutant emissions.

This layout is dynamically simulated by using the TRNSYS software, by developing a suitable simulation model in order to predict system performances. Special attention is also paid to the design of proper control strategies, aiming at optimizing the exploitation of the solar energy for electricity and heating purposes. In addition, energy, economic and environmental performances are investigated by varying the main system parameters, in order to detect the optimal configuration.

The simulation results show that the economic feasibility of the investigated case study, located in Naples (South Italy) is good, in fact this system allows one to reduce the electricity demand taken from the grid. The summer energy performance, in terms of electricity and domestic hot water production, is obviously better than the winter one, since such system is significantly affected by the solar radiation availability. Finally, a remarkable saving of CO_2 emissions can be also achieved.

SDEWES2018.0487

Thermoeconomic Diagnosis of Air Conditioning Systems: an Innovative Approach for Improved Reliability of the Technique

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Abstract

Thermoeconomic diagnosis is an exergy-based fault detection and diagnosis technique which has been recently extended to air conditioning systems. One of the main features of this technique is to provide quantitative information of the impact of each fault on the increased energy consumption of a system. This information is then used for programming cost-effective maintenance strategies. Only few papers have focused on it and a lot of work is needed for further improvements. In this work, the approach was developed by means of experimental activities carried out on a 17.5 kW packaged rooftop air conditioning unit (RTU). The RTU was tested in psychrometric chambers under a wide range of operating conditions and fault levels. Two faults that are commonly found in rooftop systems were investigated: (i) evaporator fouling and (ii) condenser fouling. Also, scenarios involving the presence of multiple faults were investigated. Experimental data were used to refine and improve the innovative thermoeconomic model proposed by some of the authors, in order to improve the technique performance. To this aim, a sensitivity analysis of some thermoeconomic parameters with a boundary conditions set was carried out. Results showed a great sensitivity with the temperature of the outdoor environment and some correlations were derived and then included within the thermoeconomic model. Also, an exergy modelling of the compressor behavior was carried out in order to filter the extra irreversibility generated in this component by faults occurring in the condenser and in the evaporator. After filtering the extra irreversibility on the compressor, results showed an improvement of the technique performance.

SDEWES2018.0638

Exergy Diagnostics of Alpha-Type Stirling Engine Driven with the Cryogenic Exergy of LNG

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Abstract

In the paper, an advanced exergy analysis of small-scale alpha-type Stirling engine is presented. This article presents the exergy diagnostics of the modelled system. The fundamental concept of the thermo-economic analysis exergy cost, as well as malfunctions and dysfunction of the analysed system, are presented. The advanced exergy diagnostic is based on the fuel and product definition of each flow considered in the system. The exergy diagnostic shows the direct and indirect losses generated with the analysed system. The exergy diagnostics results are based on the data obtained from computational fluid dynamics (CFD) model of small-scale a-type Stirling engine. The numerical model covers all modes of heat transfer inside the engine: conduction, convection, and radiation. The developed numerical model was used to assess the performance of the analysed Stirling engine. To evaluate the influence of varying heating strategies of the small-scale a-type Stirling engine the CFD was used. The novelty of this article is to present the combined CFD modelling with the exergy analysis.

Renewable energy sources 2

SDEWES2018.0170

Energy Performance Analysis of a Forced Circulation Solar Water Heating System Equipped with a Heat Pipe Evacuated Tube Collector Under the Mediterranean Climate Conditions

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Abstract

This work represents the energy performance analysis during the annual time period of a forced circulation solar water heating system equipped with a heat pipe evacuated tube collector under the Mediterranean climate conditions. For the purpose, recorded data from a field-trial installation are exploited. The recorded data obtained every min are used to perform the energy analysis during an annual period. The analysis is performed by using mathematical models and by representing the results for each month. Monthly values of useful heat gain from the solar collector, useful heat gain from the storage tank, collector efficiency, system efficiency, and solar fraction offered a clear view regarding the operation of a forced circulation solar water heating systems for this climate region. Also, the annual energy balance of the system obtained from calculation is built.

SDEWES2018.0304

Laboratory Testing of Domestic Hot Water Boiler While Fired with Different Biomass Pellets

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Abstract

This work presents combustion and emissions results obtained from burning several biomass pellets (wood and straw from different agricultural residues). Fuel analysis, net calorific value, gaseous emissions (CO, NO_x), ash agglomeration and residue analysis is provided for comparison. Tests were performed at laboratory conditions according to the relevant CEN standard in conventional type of high efficient/low emission domestic wood burning boiler, equipped with 6-26 kW rotary combustion chamber burner, particularly suitable for burning fuels with high content of non-combustible impurities. The results show that, although available on the market, not all agricultural residues are applicable for combustion in the form of pellets, among others, due to low combustion efficiency, gaseous emissions and lumped residue particles containing large amounts of unburned carbon.

SDEWES2018.0322

Economic Assessment of Renewable Energy Systems Integrating Photovoltaic Panels, Seawater Desalination and Water Storage

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Abstract

This paper analyses the integration of solar energy and water storage systems, for seawater desalination. The investigated plant includes PhotoVoltaic (PV) panels, a Reverse Osmosis (RO) unit for the seawater desalination and a Water Storage Basin (WSB). The PV panels produce electrical energy used to supply the RO unit, which converts seawater into potable fresh water. No electrical storage system is considered since the fluctuating PV electrical production determines a stable water production, due to the utilization of the WSB. In fact, the PV production mainly occurs during the central hours of the day, whereas the fresh water demand shows a significantly different profile. Therefore, fresh water production pattern follows a different trend with respect to the solar radiation, thanks to the use of a suitable water storage basin Thus, a system maximizing the water production self-consumed can be designed. The solar desalination plant is dynamically simulated by means of a zero-dimensional transient simulation model (developed in TRNSYS environment). This plant is assumed to operate in small islands in European Mediterranean Sea, rich in solar energy and seawater availability, but with a scarce accessibility of fresh water, at purchasing costs consequently very high. As main case study Pantelleria island (South of Italy) is selected. In this paper, an economic analysis is also carried out in order to evaluate the system economic profitability, as well as a suitable sensitive analysis aiming at determining the optimal values of the most important design variables.

SDEWES2018.0323

A Novel Renewable System Based on Evacuated Solar Collectors for the Simultaneous Production of Thermal Energy Cooling Energy and Desalinated Water

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Abstract

This paper presents the integration of the solar thermal technology into a novel polygeneration system, producing simultaneously thermal energy, cooling energy, domestic hot water and drinkable desalted water. In particular, the analysis was performed by evaluating the energy and economic performance of evacuated tube solar collectors, coupled to a multi-effect distillation (MED) system for seawater desalination. The system also includes a single stage LiBr-H_2O absorption chiller, storage tanks, a biomass auxiliary heater, heat exchangers, balance-of-plant devices. The solar field produces heat, at a maximum temperature of about 170°C, used for different purposes: during the winter for space heating production; during the summer to drive the absorption chiller, producing chilled water for space cooling; during whole year, for domestic hot water purposes and in combination with the heat produced by the auxiliary biomass-fired heater, it is used by the MED unit to convert seawater into desalinated water. The whole plant is simulated by means of a zero-dimensional dynamical simulation energy model, developed in TRNSYS environment. The model simulates the performance of all the components for a one-year of operation, also considering several control strategies, for the management of the whole polygeneration plant. A detailed economic analysis is also included in the model. The economic analysis shows that the system is not profitable when no incentives are available. Conversely, the economic profitability significantly improves in case of feed-in tariffs, achieving a simple payback period of about 5 years.

SDEWES2018.0394

A Long-Term Wind Resource Assessment for a Site Characterized by Seasonal and Year-to-Year Variations

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Abstract

An evaluation of the economic feasibility of a wind farm with a long-term wind resource assessment is indispensable to the development of a commercial wind farm. A short-term data measured at the candidate site of a wind farm cannot represent the long-term wind potential. Prediction errors are especially significant when seasonal and year-to-year variations exist in the candidate site. Moreover, reliable long-term reference data that is highly correlated to short-term measured data is often unavailable for onshore sites, because many geological factors, including local vegetation and artificial structures, distort wind flow. This paper presents an alternative solution to predicting long-term wind resources for a site characterized by seasonal and year-to-year variations, where long-term reference data is unavailable. Analysis shows that a k-fold cross Measure-Correlate-Predict (MCP) method is a good alternative when reliable long-term reference data is unavailable, in that several datasets measured over short-term periods are used to correct long-term wind resources in a mutually complementary manner. Moreover, the k-fold cross MCP method is useful in the evaluation of extreme wind speed, which is one of the main factors affecting the feasibility of a wind farm, as well as the evaluation of site compliance and the selection of the applicable class of wind turbine corresponding to IEC standards. Analysis also shows that the energy density is a more sensitive metric than wind speed for sites with seasonal and year-to-year variations, because of a wide-ranging distribution of wind speeds. A case study with a short-term data measured from Fujeij, Jordan, clearly suggests the factors that are necessary and important in order to secure a reliable and accurate assessment of long-term wind potentials.

SDEWES2018.0438

Machine Learning Methods for Solar Irradiation Forecasting: a Comparison in a Mediterranean Site

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Abstract

In this survey, eleven statistical and machine learning tools are analyzed and compared in view to forecast the solar irradiation. This comparison is realized and analyzed using solar data collected in Ajaccio (Corsica, France, 41°55N, 8°44E, 4m asl). The forecasting horizon is from 1 to 6 hours with an hourly time granularity. The evaluation of the variability in the datasets is made by the calculation of the mean absolute logreturn. 11 forecasting models are compared: persistence, scaled persistence, auto regressive mobile average (ARMA), multi layer perceptron (MLP), regression trees, boosted regression trees, bagged regression trees, pruned regression trees, random forest, Gaussian processes and support vector regression. The models are compared in term of error metrics: nRMSE (normalized root mean squared error), MAE (mean absolute error) and skill score related to the smart persistence. At last, the most efficient models are selected for every variability and every temporal horizon.

Biofuels, bioenergy and biorefineries 2

SDEWES2018.0077

Kinetics and Mechanism of the Butanolysis of Rapeseed Oil

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Abstract

Biodiesel is a mixture of esters of fatty acids (most often palmitic, stearic and oleic) and lower alcohols (in our work butanol) produced by transesterification. It is usually used as a renewable source of energy. The sources for preparation are triacylglycerides, which are contained in vegetable oils and animal fats. This work focuses on alkaline catalyzed transesterification of rapeseed oil with butanol. The reaction catalyzed by KOH is described by a model consisting of two sequences of consecutive competitive reactions. The first sequence expresses the butanolysis of rapeseed oil to butyl esters (biodiesel) whereas the second sequence describes the always present side reaction-saponification of glycerides and butyl esters by KOH. The proposed chemical model is described (after rational simplifications) by a system of differential kinetic equations which are solved numerically by two independent computing methods. The thus obtained theoretical kinetic and equilibrium results are compared numerically and/or graphically with the experimental parameters. The latter were obtained by the determination of the relevant components in the actual reaction mixture by analytical methods. According to the experimental results, the proposed reaction scheme is fulfilled with high probability. The optimal average rate constants and equilibrium constants of individual reaction steps of the discussed scheme are introduced. The limitations of the proposed reaction model are discussed.

SDEWES2018.0140

A Comparative Life Cycle Assessment of Biogas Production Based on Pig and Cattle Manure

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Abstract

The main problem associated with livestock breeding is high rates of methane emissions. The large volume of manure generated needs adequate disposal, making Brazil a potential producer of biogas. This article reports a comparative life cycle assessment of biogas production from pig and cattle manure to assess their respective contributions to greenhouse gas (GHG) emissions. The boundaries included the finishing, manure management and anaerobic digestion (AD) phases. The method included consultation of Intergovernmental Panel on Climate Change reports and application of SimaPro 8.0 software. We found that making biogas from pig manure has higher emissions than from cattle manure, in all stages evaluated: 2.3 times higher in manure management, 1.6 times higher in finishing phase and 1.08 times higher in AD processing. The manure biogas final impact from cattle is half of that from pig manure, because of differences in allocation factors. By using manure as substrate for biogas production, it ceases to be a livestock residue and becomes a product, whose use reduces GHG emissions.

SDEWES2018.0155

The Effect of Plastic Co-Feeding on the Production of Aromatic Hydrocarbons During the Catalytic Pyrolysis of Biomass

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Abstract

Owing to the increased demand for the renewable energy, many researchers are investigating the thermal and catalytic pyrolysis of biomass. Although large amount of bio-oil can be produced by the simple fast pyrolysis of biomass, its quality is not proper to be used as a fuel or chemical feedstock due to its instability and low selectivity. To overcome these limitations, catalytic pyrolysis is widely applied on the thermal conversion of biomass to increase the yields of aromatic hydrocarbons or other valuable chemical feedstock.

Recently, several researchers are focusing on the catalytic co-pyrolysis of biomass and waste plastics. By co-feeding the waste plastics, such as HDPE, PP, and so on, much larger amounts of aromatic hydrocarbons can be obtained for the mixture of biomass and plastics. Synergistic formation of aromatic hydrocarbons due to the effective interaction between reaction intermediates of biomass and plastics during catalytic pyrolysis is the main advantage of catalytic co-pyrolysis process.

In this study, catalytic co-pyrolysis of biomass and waste plastics was investigated using a tandem micro-reactor-gas chromatography/mass spectrometry. The effect of experimental parameter, such as reaction temperature, catalyst to sample ratio, biomass to plastics mixing ratio, and so on, were tested to optimize the process for the production of aromatic hydrocarbons. Experimental yields of aromatic hydrocarbons obtained from the catalytic co-pyrolysis were also compared with their theoretical yields to discuss the synergistic effect on the production of aromatic hydrocarbons.

SDEWES2018.0351

Thermal and Catalytic Conversion of Lignin and Refuse Derived Fuel over Zeolites

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Abstract

Lignin is a component of wood biomass which has a complex chemical structure of phenol polymer, and refused plastic fuels (RPF) is a solid fuel made from waste plastics. These two materials have great potentials to produce phenolics, paraffins, olefins, and aromatic compound(e.g. BTEX) by various conversion processes. Pyrolysis is one of a reasonable conversion process that produce a liquid product called bio-oil by thermal decomposition of feedstock without oxygen supplying. But also bio-oil contain some oxygen, acidic compound and have higher viscosity caused quality and stability degradation. In this study, catalytic vapor cracking over zeolites for upgrading bio-oil from lignin and RPF pyrolysis was investigated. Commercially available ZSM-5, Y and Beta zeolites with various alumina ratio were used for experiments. Nickel and gallium impregnated zeolite with various weight ratio were also tested by lab scale batch reactor. Product yields of thermal and catalytic conversion of lignin were about 25~35% liquid, 15~25% gas and 50% char. Liquid product mainly consisted of phenolic compounds and aromatic compounds. In case of RPF, product yields were about 18~55% liquid, 32~67% gas and 13~15% char. Liquid product by RPF decomposition and catalytic conversion mainly consisted of aromatic compounds and aliphatic hydrocarbons. Main reactions of pyrolysis and catalytic vapor cracking were deoxygenation, aromatization, polymerization, decarboxylation and decarbonylation. The most effective catalyst for upgrading bio-oil was Ga/HZSM-5. Ga/HZSM-5 increased mono- aromatics content in bio-oil. Meanwhile, Ni/HZSM-5 was not so effective in terms of bio oil. Ga/HZSM-5 also showed the excellent performance for resistance to the formation of coke while large amount of coke was formed by HY and HBeta

SDEWES2018.0371

Detailed Modelling of Biomass Gasification Process in Dual Fluidised Bed Gasifier Validated by Experimental Data with Comparative Study of Temperature Impact

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Abstract

Biomass energy conversion is a very reliable way to produce energy and chemical products to compare with other renewable sources such as wind, solar and wave which have intermittent nature. Amongst different methods of converting biomass to energy, the thermo-chemical process of steam gasification is a very promising way, since it enables a subsequent poly-generation process that produces heat, electricity, synthetic natural gas and synthetic chemicals such as methanol, Fischer-Tropsch diesel, gasoline and kerosene.

Modelling of biomass gasification process is a powerful tool to optimize process designs but remained a challenge due to its high complexity. A new approach is used to model this process in a 100 kW circulating dual fluidized bed with the detailed pyrolysis modelling as a key factor for more accurate results. The results have been validated by experiments conducted with softwood pellets as the fuel and fresh olivine sand as the bed material. The impact of the temperature variation of the gasifier on the final product gas composition is measured in the experiments and analysed in the simulation to have a better insight on the pyrolysis process, the heterogeneous reactions of char as well as the deviation from equilibrium of the water gas-shift reaction.

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Effect of Nanoparticle on Combustion and Emission Characteristics of Jatropha Biodiesel

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Abstract

Sustainable biofuels could potentially replace huge quantity of fossil fuels to tackle harmful greenhouse gas emissions and their impact on health and wellbeing of the living beings. However, upgradation of biofuels are required to optimise the combustion and emission characteristics of the biofuels operated internal combustion (IC) engines. In this study, jatropha biodiesel (JB100) was produced from neat jatropha oil using both esterification and transesterification processes. The free fatty acid value of neat jatropha oil was reduced to approximately 2% from 12% through esterification. Transesterification was carried out on the esterified oil to produce jatropha biodiesel. Aluminium oxide (Al_2O_3) and cerium oxide (CeO_2) nanoparticles were added separately to jatropha biodiesel with the aid of a surfactant and an ultrasonic machine in doses of 100ppm and 50ppm respectively. The heating value, acid number, density, flash point temperature and kinematic viscosities of the fuel samples were measured and compared with the corresponding properties of neat fossil diesel and neat biodiesel. Jatropha biodiesel with 100ppm Al_2O_3 nanoparticle (JB100ALN100) was found to be a suitable alternative fuel due to its higher heating value and successful amalgamation of the Al_2O_3 nanoparticle used. Engine test results showed that the brake thermal efficiency of JB100ALN100 fuel was about 3% higher than for neat fossil diesel. Furthermore, the thermal efficiency of JB100ALN100 fuel was quite similar to that of neat jatropha biodiesel. At full engine load, the brake specific energy consumption of JB100ALN100 fuel was found to be 4% higher and 6% lower than the corresponding values obtained for neat jatropha biodiesel and neat fossil diesel fuels respectively. At full engine load, the NOx emission was found to be 4% lower with JB100ALN100 fuel when compared to jatropha biodiesel. The unburnt hydrocarbon and smoke emissions were decreased significantly when B100ALN100 fuel was used in the engine instead of neat jatropha biodiesel or neat fossil diesel fuels. Combustion characteristics showed that in almost all loads, JB100ALN100 fuel had a higher total heat release than the reference fuels. In addition, at full load, JB100ALN100 fuel gave the highest peak cylinder pressure. The ignition delay and combustion duration parameters of the JB100ALN100 fuel were also compared with the corresponding values of the reference fuels. The study concluded that JB100ALN100 fuel could be used in the compression ignition engine to achieve better combustion and emission benefits than pure jatropha biodiesel.

Research, innovation and development

SDEWES2018.0135

Photooxidation of Triclosan Using Nanostructured Catalysts

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Abstract

Today, organic anti-microbic substances have increased the concern due to their potential health effects on human and natural life. Triclosan is one of the commonly used in personal care products known as anti-bacterial or anti-microbic, certain fabrics and kitchen including liquid soaps, toothpaste and cleaning products. There are strong evidences that water plants and other aquatic species are more sensitive to Triclosan. New products resulting from decomposition of Triclosan which is easily found at the outlet water of waste water treatment plants and discharged to the receiving environment with the outlet water of these plants show endocrine disturbing properties and give damage to aquatic eco-system and human health in the long term. Purpose of this study was to investigate the elimination of Triclosan (TCS) from wastewater by using photo-oxidation method. Removal of TCS was investigated using UV oxidation and combined with Nafion/iron catalyst. Immobilization of iron on the perfluorosulfonic polymer, Nafion®, has been investigated as a carrier for the oxidation of pollutants by hydroxyl radicals (heterogenous photo-Fenton mechanism). However, the low surface area of Nafion, less than 0.2 m^2/g, usually results in low pollutant degradation rates. Sol-gel technology was used to produce a high surface area poly(dimethylsiloxane) (PDMS) modified Nafion/silica composite suitable for catalysis of the photo-Fenton reaction without significant leaching of iron. The incorporation of Nafion into silica greatly increases the accessibility of Nafion/iron loaded active site. PDMS reinforces the structure of silica and maintains the transparency of the composite, which is essential for efficient Photo-Fenton reactions. These composites was utilized for the decomposition of TCS. In consequence, it is clear that the composite effectively catalyses the photo-Fenton reaction to remove TCS. The presence of iron through the use of the catalyst leads to rapid degradation of the TCS compared to just H_2O_2 and UV light alone. It was found that the addition of only 34 mg/L H_2O_2 produced more than %90 conversion of TCS within 60 minutes.

SDEWES2018.0278

Rapid Exfoliation of Kaolinites and Evaluation of Emulsion Stabilization Performance for Oil Recovery Application

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Abstract

Oil/water emulsions stabilized by solid particles, which are called “Pickering emulsions”, are widely used in food, pharmacy and cosmetics industry and have been proposed for oil recovery in the oil industry. In recent years, two-dimensional (2D) nanoplatelets were found to be good emulsion stabilizers. As a 2D material, exfoliated kaolinites have been extensively studied because of their unique properties and various potential applications.

In general, kaolinites can be exfoliated by grinding and/or intercalation, which is usually complex and/or time-consuming, requiring at least several days, because the process is conducted near room temperature and/or by traditional convection heating. Therefore, kaolinites should be exfoliated by using simple and rapid methods.

In this research, a simple rapid one-step microwave-assisted method was proposed for kaolinite exfoliation. The exfoliation was verified by investigating the crystallinity, structure, morphology and size distribution of kaolinite were investigated using various methods including X-ray diffractometer (XRD), Fourier transform infrared (FTIR), scanning electron microscope (SEM), transmission electron microscope (TEM) and dynamic light scattering (DLS) analysis. The potential application of the exfoliated kaolinite for emulsion stabilization was studied.

Results indicated that exfoliated kaolinite platelets were obtained without notable lateral size reduction compared with that of the raw kaolinite. The dodecane/water emulsion stabilized by the exfoliated kaolinite remained stable for more than 60 days. The good performance of the exfoliated kaolinite nanoplatelets in stabilizing the emulsions suggested the effectiveness of the kaolinite exfoliation method and application potential of the novel exfoliated kaolinites in oil recovery industry.

SDEWES2018.0404

Analysis of a Bio-Plasticizer Production Unit from Biodiesel

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Abstract

In 2016, the global plasticizer market was 8.4 Mt. Phtalates constitutes the 70 % of the overall production. Despite their unique physicochemical properties (high solubility in the polymeric matrix, low volatility and facile synthesis), most of the esters of phthalic acid poses health concern and lead European Union to restrict their percentage in plastic to a level below the 0.1 % by weight in June 2017.

Epoxidized vegetable oils (EVOs) may act as plasticizer and substitute phthalates especially if applied to poly vinyl chloride (PVC). Sulphuric acid catalyses the reaction between the unsatured fraction of oil (molecules that bear at least a double bond on the carbon chain) and peroxyacetic acid, which acts as active oxygen carrier and it is obtained by the reaction of acetic acid and hydrogen peroxide. However, the solubility of EVOs in PVC is low, which makes these products unable to substitute phthalates, whose typical concentration in polymer ranges from 0.5 to 45 % by weight.

In a previous paper, we explore epoxidized soybean biodiesel (ESB) as an alternative to EVOs. Biodiesel is a mixture of fatty acid methyl esters. Its molecular weight is about one third the one of vegetable oil and his epoxide acts as a primary plasticizer and may be a substitute of phthalates. We also identified a strategy to maximize the oxirane content in the final product by distilling the raw biodiesel and concentrating it into unsatured molecules. However, even though our ESBs are comparable to commercial bioplasticizers in terms of oxygen content, no information is available on the cost of a unit operation to produce ESB via our synthetic root. In this work, we model the epoxidation reaction of soybean biodiesel and by simulating a unit operation that produces ESB. A Python script calls iteratively a PRO/II 9.3 simulation file (SimSci Scheider Electrics, static simulation software) that numerically reproduces the distillation of soybean biodiesel. A MATLAB 2018b script solved the kinetic equations and cslculsted liquid-liquid equilibrium state at each instant of the reaction (the reaction occurs in a biphasic liquid system). The activity coefficients of each component are computed using the UNIFAC equations. We estimated the operative and capital costs, and eventually we found the best techno-economic ESB production conditions.

SDEWES2018.0489

Importance of the Sub-Processes in Solid-Fuel Particle Gasification: Heat Conservation and Reaction Mechanism I

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Abstract

The aim of this article is to develop a complete and detailed gasification model for a single solid fuel pellet. Three main objectives are achieved: a modified one-dimensional model using C++ code, a reliable results validation using experimental data from literature and an overview of the detailed one-dimensional model results. This model is based upon the partial differential equations (PDEs) describing continuity, species transport, energy and pressure equations. All the equations are highly coupled and are solved using a central-differential scheme (CDS). A time-marching procedure is based on a fully implicit scheme. Both a grid independent validation and a validation against experimental data are given in the paper. The validation results show good agreement with the experimental data. The temperature profile, the definition of the end of each pyrolysis/gasification stages and the effects of sensible enthalpy are presented.

SDEWES2018.0521

Innovative Model of Education in Sustainable Energy Education in Innoenergy Programs

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Abstract

The Innoenergy master school has started its mission in 2010. European Institute for Innovation and Technology (EIT) supports Innoenergy as the leading engine in changing educational landscape in engineering education especially focused on entrepreneurship in sustainable energy in Europe. Since 2010 Innoenergy Master School offers master's degree programs, which are designed as a new type of education offer delivering not only knowledge but shaping skills related to expert knowledge together with business and soft competencies. All programs are reviewed by EIT experts in order to receive certificate of the alignment with principals of modern education. The process of transition of Master school and its newest achievements is presented in the manuscript. Especially process of implementation of pedagogical evolution principles on the example of the leading program in Innoenergy Master school's offer - Clean Fossil and Alternative Fuels Energy - is discussed extensively in the manuscript.

SDEWES2018.0539

Improvement of Palm Oil Biodiesel Filterability by Treatment with Reactivated Spent Bleaching Earths

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Abstract

ASTM D6751 standard specification requires that biodiesel have a cold soak filtration time (CSFT) below 360 s; however, palm oil biodiesel (POB) is characterized by a failing CSFT. Reactivation and reuse of spent bleaching earths (SBE) to improve POB filterability was examined in this study. SBE was reactivated by washing with hexane, heating, and a combination of heating and acid treatment. Solvent extraction of residual oil alone was found not to be an effective method for reactivation of SBE; in contrast, an adsorbent capable of achieving the needed filterability was obtained through either heating treatment or the combined heating and acid treatment. There was no significant difference in CSFT and the precipitate content between biodiesel treated with the reactivated adsorbents at 5 and 3 mass%. In contrast, biodiesel treated with 1 mass% failed to meet the ASMT limit for CSFT.

Environmental policy and management

SDEWES2018.0083

A Review of Drivers and Barriers for Implementing Circular Economy and Sustainable Development Goals in the EU-13, Focusing on Logistics

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Abstract

The United Nations has adopted the Agenda 2030 with 17 goals, tracking the most pressing social and environmental challenges. Achieving the goal 12 requires a complete shift from existing linear to a circular system. The European Union (EU) plays an instrumental role in shaping the Agenda 2030, and ensuring the implementation of SDGs within the EU. In 2015 the European Commission (EC) adopted the Circular Economy Action Plan. Innovative ideas regarding cleaner and sustainable logistics and transport services and business models will drive the transition to sustainable development. With the implementation of the CE package the EU has the potential to become a world leader in eco-innovation, with the benefits from global perspective. Furthermore, for effective participation in decision-making it is critical to achieve awareness, values and attitudes, skills and behaviour that are consistent with SD. Logistics industrial sectors lack appropriate knowledge in identifying and implementing the principles of CE and SCP. In our paper, a review of policy recommendations in the EU-13 and their implementation were carried out considering drivers and barriers. In addition, challenges of financial mechanisms supporting circular economy in logistics will be considered.

SDEWES2018.0116

Do Environmental Policies Induce a Green Paradox? A Structural Break Analysis of Global Fossil Fuel Supply and Carbon Dioxide Emissions

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Abstract

This paper presents one part of an empirical analysis of the green paradox. According to the green paradox theory a well-intended but imperfectly implemented environmental policies may lead to detrimental outcomes due to supply side responses. The main hypothesis for this analysis is based on the literature review, which showed that research of the green paradox has been mainly focused on theoretical works so far. Hence, this analysis investigates, whether the theory of a green paradox can be empirically proven globally. Therefore, the first of the two empirical analyses should answer the question, weather the production of fossil fuels (oil, natural gas and coal) and carbon dioxide emissions increased significantly after the Kyoto Protocol. The theory predicts that owners of fossil fuels, expecting future sales to decline, would supply significantly more of their resource since the announcement of this global environmental policy.

A literature review showed that empirical studies on structural breaks of the production of fossil fuels and carbon dioxide emissions are scarce and mainly focus on price shocks of fossil fuels and their consequences. The empirical structural break analysis of global data therefore delivers new insights and scientific valuable results concerning the behaviour of fossil fuels producers.

Using data on longest and best available records for each fossil fuel source and carbon dioxide emission, this study finds a strong evidence of a significant production increase of coal, some indication that the amount of carbon dioxide emission might have increased, and no evidence of a significant production increase of oil and natural gas since the announcement of the Kyoto Protocol. In addition, broken down to the largest coal producing countries, it was found that China is mainly responsible for the significant increase in global coal production.

Overall, this research suggests that while the mechanism indicated by the theory seems to be working for coal, market conditions and the concurrent regulation largely prevented a green paradox from arising for oil and natural gas up to now. These results have implications for the design of energy policies and emission markets, as well as the use of primary energy resources.

SDEWES2018.0144

Overcoming One-Way Impact Evaluation of Rural Electrification Projects

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Abstract

In their recent study on impact evaluation in rural electrification research, Riva et al. [9] call for more research on reverse feedback and complexities of rural electrification projects. The purpose of this study is use this as a starting point to analyse socio economic dynamics of rural electrification under the perspective of a more holistic approach. Impact evaluation in rural electrification research usually studies the effects under the framework of an one-dimensional approach from electrification to socio-economic development and/or vice versa. However, for planners, regulators and investors it is of essential importance to know about the multi-dimensional complexities rural electrification projects face to make their planning easier. For this purpose, this paper studies effects of electrification on daily lighting, lumen and operating hours of micro enterprises. It is based on a case study of a with the main grid interconnected mini-grid project located in Mufindi, Iringa, in the Southern Highlands of Tanzania. Propensity Score Matching Method is applied to identify control and research groups. Quantitative information is combined with qualitative data to allow for a comprehensive overview on dynamic interactions between electricity demand and the local market structure. Grid-electricity has significant impacts on quality of lighting, but no significant impacts on lighting and operation hours can be identified. Off-grid systems, consisting of solar technologies, might already meet a major share of electricity demand, whereas complementary activities and infrastructures, such as access to markets, are needed to stimulate electricity demand and business development. Fertile ground for further research is identified.

SDEWES2018.0172

Waste Transportation and Facility Location Based on Cost and Impact of Emissions

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Abstract

The world is being constantly overpopulated which is connected with the increase of production and industrialization. Such a development is reflected also in the waste management area where the amount of waste produced is higher every single year. This results in the requirement of a sustainable network of treatment facilities to meet the demand for processing. Regarding mixed municipal waste, which is the residual waste after removing recyclable fractions by citizens, the Waste-to-Energy plant seems to be a suitable option as it substitutes both landfills and burning of fossil fuels in combined heat and power plants. However, new projects when sited need to take into account surrounding conditions of heat and electricity demands to ensure the economic stability, but also environment and population threats should be considered. The paper proposes a novel strategy in facility location problems with regards to the population living close to treatment facilities and transportation roads, total costs and global warming potential. The number of inhabitants, the amount of emission produced and their distance play an important role in impact evaluation. A multi-objective core of mixed integer linear programming model is presented to assess these possibilities in the waste management sector. The local and global aspects are combined for holistic approach formulation. The approach considers also the avoided emissions by replacing the fossil fuels. The network features should be evaluated through emission edge characterisation and dispersion studies. These studies are analysed in detail and used to formulate the function for facility impact. The whole model will serve stakeholders and investors as decision-making support because protests of inhabitants due to traffic, health or environmental concerns are taken into account as well. Thus, the trade-off between cheap and socially acceptable solution can be suggested.

SDEWES2018.0319

Defining Sustainable Action Plans in Metropolitan Cities Using the Fuzzy Analytic Hierarchy Process Group Decision Analysis

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Abstract

The formulation and selection of planning strategies promoting the smart development of metropolitan cities, aggregates of functional urban areas with decentralized control and governance that extends beyond the core administrative/political city is a far from straightforward process. It suffers from the problems inherent in the intelligent urban development and sustainable socio-economic growth of cities as well as from new issues deriving from the spatial and structural characteristics of the metropolitan city. This paper applies the Fuzzy Analytic Hierarchy Process multi-criteria decision-making technique to a smart metropolitan city context. The aim is selecting the optimal strategy for the smart development of metropolitan cities in a set of candidate action plans, while using multiple performance indicators, and taking into account that several decision makers may be involved in the planning decisions. The developed approach adopts the indicators defined by the SDEWES (Sustainable Development of Energy, Water and Environment Systems) Index framework, which focus on the key aspects of smartness related to energy, water, and environment. The approach is then applied to the real case of Bari (Italy), with the aim of selecting the optimal mix of flagship projects (within a list of flagship projects implementable in each strategic areas of the metropolitan city of Bari) that allows gaining this objective (sustainability) with a given amount of available resources. The findings highlight that the proposed method is suitable for selecting smart development action plans, allowing taking into account multiple perspectives in the comparison, while supporting group decision making and modeling the uncertainty that clearly affects the evaluation. Furthermore, the discussion of the results shows how such an approach may practically support local government's decision makers in defining the optimal strategy to promote innovation of the organizational and management structure of a metropolitan city in a smart perspective.

SDEWES2018.0555

Dermal Bioaccessibility of Metals in Polluted Soils: Influence of Artificial Sweat Composition

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Abstract

Children are regularly exposed to toxic substances such as metals and metalloids via multiple pathways, including incidental dust ingestion, inhalation of particulate matter (PM), and dermal contact with soils. Finer fractions soils and mine tailings, and their associated PM may contain high levels of metals, and therefore can contribute to health risks depending on the exposure pathway. Dermal contact has often been overlooked when assessing exposure to the fine fraction of soils since the ingestion route is traditionally considered as the most important exposure pathway. However, for some metals such as Pb, Cr, and Ni, skin contact is potentially an important exposure route. Solubilisation of metals in skin surface liquids may result in contaminant transport into the systemic circulation.

Bioaccessibility can be used as an estimation of bioavailability and, when available, in-vitrobioaccessibility tests might be preferred over in-vivobioavailability tests for their cost advantage and ethical considerations. Incorporating contaminant bioavailability and using bioaccessible concentrations instead of total concentrations in human health risk assessment studies should provide more accurate results.

In vitrosolubilisation tests using physiologically based synthetic skin surface fluids (artificial sweat) can provide accurate estimates of contaminants bioaccessibility. Release of metals from soils in contact with skin is assessed using synthetic skin surface liquids but sebum lipids such as wax esters, triglycerides, and fatty acids are generally not included in the developed formulations.

The present study aims to (1) characterize and measure Cr, Ni, Pb, and Zn concentrations in certified reference soils SQC 001(Sigma-Aldrich) and BGS 102 (British Geologival Survey) and (2) compare the dermal bioaccessibility of these metals using three synthetic sweat formulations (including EN 1811 and NIHS 96-10) and various sebum formulations.

The paper will also highlight the research needs to properly use the dermal bioaccessibility values in order to improve human health risk studies, therefore allowing for better protection of children and workers exposed to contaminated sites.

Vehicles and transport

SDEWES2018.0006

Strategic Metals Ranking in the Automobile Sector

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Abstract

A conventional passenger vehicle demands more than 50 different types of metals, some of them such as tantalum, indium, niobium or rare earths elements (REE), are considered critical by the European Commission. Besides this, their functional recycling is practically absent. Moreover, the transition to fully electric vehicles will require more electrical and electronic devices, motors and batteries that will need an increasing amount of critical metals.

With the aim to identify possible future metal supply constraints, an own methodology has been developed and applied to the automobile manufacturing industry. This approach defines a variable called Strategic Metal Index (SMI) which is calculated for each metal. The SMI is the result of combining the following parameters: (1) Automobile sector demand with respect to world production; (2) Available reserves; (3) Known resources; (4) Metal production capacity; (5) Economic importance and (6) Supply risk. Together with another methodology called thermodynamic rarity developed by the authors, they should provide a holistic decision support tool for raw material strategic planning in the automobile sector.

The SMI has been applied to 50 metals used by different types of vehicle powertrains. The assessment covers metal demand from 2018 to 2050 according to vehicle sales projections for five different scenarios.

This assessment reflects as main possible constraints: Ni, Li, Co and Mn (batteries); Nd and Dy (permanent magnets); Pt (catalytic converters); Tb (lighting and fuel injectors); Sb (steel alloys and paintings); Au, Ag and Ta (electronics); In (screens); Te (steel alloys and electronics) and Se (sensors and glasses).

SDEWES2018.0097

Decarbonizing the Transport Sector: the Promethean Responsibility of Nicaragua

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Abstract

The transport sector is the second largest energy consumer in Nicaragua and it relies solely on oil derivatives. It is growing at an unsustainable rate and Nicaragua must explore alternative transport pathways to decarbonize this sector. This study developed 5 scenarios to assess transport alternatives for Nicaragua such as a mass public transport system for the country's capital, the adoption of electric vehicles, and a shift to synthetic fuels. The scenarios reflect the Nicaraguan energy system in 2030 after the implementation of these alternatives. The results show that the most cost-effective alternative to stabilize transport demand is public transport. Electric vehicles and electrofuels create synergies between the electricity and transport sector making them suitable options to integrate higher shares of variable renewable energies in the generation matrix. These synergies increase the overall efficiency of the system and provide flexibility to balance the fluctuations of variable energy sources and demand.

SDEWES2018.0118

A Review of Available Chargers for Electric Vehicles: USA, EU and Asia

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Abstract

This research focuses on the incompatibility of chargers for electric vehicles between different vehicle brands and types. The basics of electric vehicles and their charging is presented. The three biggest electric vehicle markets (USA, EU and Asia) were studied to establish which electric vehicles and with what kind of chargers were sold in the last three years. Also included is the market share of existing publicly accessible charging points for every market. A short overview of various countries' policies for these markets is included as regards promoting and favouring electric vehicles and standardising the chargers. A comparison is made between the required charging capacities and the existing capacities, and a commentary regarding the policies of the three markets included is provided.

SDEWES2018.0119

Autonomous Vehicles from Consumer Perspective and its Possible Future Development and Energy Savings

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Abstract

Autonomous vehicle is a type of vehicle technology programed to be able to drive by itself without human interactions. Due to revolutionary idea, addressing public perception and forecasting technology development of autonomous driving is highly important. Therefore this paper focuses on knowing and awareness as well as general public opinion on autonomous vehicles, possible future development of autonomous vehicles and economic issues including willingness to buy it, potential benefits and risks reflecting their integration on roads and evaluating most important benefits which were identified to be energy efficiency and road safety. Study was carried out with use of different questions related with most important issues identified throughout literature review on autonomous vehicles. Paper is focused on autonomous vehicles in Slovenia and results were cross-compared with data on China, Japan, India, UK and USA. Results have shown that even if Slovenian survey was carried out 2 years after survey in other countries smaller share of Slovenians know autonomous vehicles and are in general less positive about them than in other countries. Less people were interested in purchasing autonomous vehicle in the near future and pay extra fee for autonomous features. It was concluded that public perception on autonomous vehicles in Slovenia is less positive than in other compared countries. However autonomous vehicles are on the rise and significant share of participants believe that they will become dominant transport mode in the next ten years and will enable us to reduce transport related energy use and increase vehicles energy efficiency as well as to improve road safety and spend time more efficiently instead of managing vehicles while being in the car.

SDEWES2018.0493

Neural Network-Based Modelling of Energy Demand and All Electric Range of an Extended Range Electric Vehicle

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Abstract

In this paper, transport energy demand modelling based on deep neural networks is elaborated and proposed. The energy demand prediction is done based on a driving cycle used as a model input, and in order to serve as a static input to neural network, the procedure for pre-processing of driving cycles and transforming them into 1D or 2D static maps is proposed. Several architectures of deep feedforward neural networks are considered and verified for this application along with different formats of model inputs. The proposed modelling approach is analysed and verified based on data generated through numerous simulations of extended range electric delivery vehicle model over a large dataset of driving cycles recorded for the case of real conventional delivery vehicle fleet. Finally, two energy demand models are derived; one predicting state-of-charge and fuel consumption at destination, and one predicting all-electric range; and validated on a testing dataset and compared to traditional map-based response surface approach.

Smart energy systems

SDEWES2018.0010

Photovoltaic and Electric Energy Storage Systems for Seasonal Base Load Provision and Self-Supply of Residential Buildings

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Abstract

This work focuses on the production and storage of renewable power with photovoltaics on building level. The aim is to provide base load of a household over the year. A battery-type electric energy storage is used to balance the daily load shift. The dimensioning of the photovoltaic plant is sized to cover the power demand all-season. The electric energy storage system is designed to retain excess power for base-load feed into the grid. Based on real time measurement data, an average annual production curve has been calculated and combined with a standardized load profile. For the considered building, the results show that an 8.7 kWp photovoltaic system with an attached storage system with 19.1 kWh effective capacity covers the power demand of an average winter day (0 – 24 h; December until February). In the remaining months, additional constant electricity output is supplied to the power grid.

SDEWES2018.0049

Power System with Large Share of Renewable Energy Source and Role of Electric Vehicles in Increasing Power System Flexibility– Case Study Croatia

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Abstract

Large penetration of fluctuating renewable sources into the power system requires a substantial increase in the capacity of various energy storages. One of the most prominent options today is the penetration of electric vehicles, whose use reduces air pollution, while connecting them to the smart grids creates the possibility to increase the flexibility of the power system, since vehicle batteries could be used as storage but also as a source of electricity.

The power system of the Republic of Croatia was modelled using the PLEXOS energy market simulation software and, based on results of different scenarios, the role of large penetration of electric vehicles in increasing the power system flexibility with a large share of renewable sources was observed.

In the model, real data for wind and PV plants production in the Croatian power system was used, with the help of the PLEXOS tool, while electric vehicles were also modelled. The results of simulations have shown the advantages and disadvantages of the integration of electric vehicles into the system.

The design and the analysis of the developed model of the Croatian power system showed that, in the future, electric vehicles could play one of the key roles in increasing the flexibility of the system with a large share of renewable energy sources.

SDEWES2018.0073

Application of Electrochemical Energy Storage Technologies as Key Parameters for Optimal Dispatch in Microgrid

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Abstract

Energy storage systems have demonstrated capabilities of improving the flexibility of power grids by providing a reliable source of energy in the face of unexpected changes in electricity demand and sudden loss of supply. In microgrid capacities (50-8000kWh), energy storage typically exists in the form of Electrochemical Energy Storage (EES), and their integration into the overall system has been considered an indispensable step in the optimal planning dispatch. Performances of several EES technologies ranging from the traditional lead acid batteries to the modern day lithium-ion batteries in the range of 300kWh-2000kWh capacities have been evaluated in a polygeneration plant layout which supplies both electricity and cooling power to an eco-building. The optimal dispatch problem is solved using a mixed integer quadratic programming, which determines the optimal charge and discharge pattern of the EES. The performance index of the EES considered such as round trip efficiency and depth of discharge are shown to have a significant impact on the daily operational cost of the plant. A techno-economic analysis has also been carried out by determining the Net Present Value (NPV) of the overall plant layout after a 20 year period in order to assess the financial viability of the different ESS technologies, showing which configuration better balance the weights between the capital and the operation expenditures, respectively.

SDEWES2018.0087

Capacity Tariffs and the Impact on Battery Charging: a Heuristic Approach

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Abstract

This paper investigates the impact of capacity tariff design on microgrids. While the possible benefits for utilities of capacity tariffs are well researched, comparatively little work has been done investigating the effects of capacity pricing on prosumers. Through simulating a grid connected microgrid and solving the day-ahead dispatch problem for a calendar year, we show that a well-designed capacity tariff will not only smooth out demand profiles, but could also lead to less erratic charge/discharge cycles in a real-time pricing scenario, lessening battery degradation. These results show that a properly designed capacity tariff has the potential to be beneficial for both the utilities as well as the battery-owning prosumer. Furthermore, we propose a new, heuristic approach to solve the day-ahead economic dispatch problem, which we prove to be effective and efficient. Additionally, we demonstrate that our novel approach does not impose mathematical restrictions such as continuous differentiability of the objective function.

SDEWES2018.0115

Data Driven Clasification and Forecasting of Residental Load Profiles

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Abstract

Smart meter systems allow us to follow and record the energy consumption behavior of individual households. The gathered data can then be used to study the consumption habits of individual user, clusters of users or a global bulk of user. In addition to gaining knowledge about the consumption habits we can develop mathematical models, which behave in a similar way the user does. Such models are used to make predictions, which are needed for the proper long-term planning of transmission and distribution networks as well as short-term scheduling and security functions of an energy management system. Herein we study how different data aggregation techniques influence forecasting accuracy of three data driven forecasting models. Our results give new insights about the factors that determine the accuracy of forecasting models and their forecasting potential.

SDEWES2018.0219

Economical, Environmental and Exergetic Multi-Objective Optimization of District Heating Systems on Hourly Level for a Whole Year

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Abstract

District heating systems are proven to be effective way of increasing energy efficiency, reducing environmental impact and achieving higher exergy efficiency than individual heating solutions. The leaders in district heating integration are Scandinavian countries with more than 50% of the covered total heating demand. Nevertheless, these systems haven't reached their full potential in the most of European countries. The reason for this could be that energy planners often study only economical feasibility of the system thus neglecting other two crucial aspects of the district heating previously mentioned. In research papers, district heating multi-objective optimization usually takes into account minimization of the total discounted cost and environmental impact. Most of the times, these two objectives are studied as a single objective optimization problem through internalization of the cost related to the carbon dioxide emissions. This paper presents novel multi-objective optimization method which is capable of optimizing district heating technology supply capacities and their operation, including the thermal storage, for one-year time horizon in order to satisfy the optimization goals. The model was written in the open-source and free programming language called Julia, while linear programming solver named Clp was used to obtain the solution. The solver is part of the Julia's optimization package called JuMP. Three separate objective functions are included in the model: minimization of the total discounted cost, minimization of the environmental impact in terms of the carbon dioxide emissions and minimization of exergy destruction. Since these three goals are often in conflict, the final result of multi-objective optimization is so called Pareto front which presents the compromise between all possible results. To deal with the multi-objective optimization problem, weighted sum method in combination with epsilon-constraint method was used. The most suitable result has been chosen using the knee point method which is a solution the closest to the Utopia solution where all three goals reach their optimal value.

Sustainability comparisons and measurements 2

SDEWES2018.0046

Implementation of LCA and ELCC as Supporting Tools to Identify the Core Sustainability Hotspots Along Product Life Cycle, Headed to Draw Guide Strategy for Automotive Product Developments Decisions: Results from Real Case Study Application

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Abstract

In the last few decades, companies have given the orientation toward the implement of internal strategies to develop effective systems to reduce the environmental impact of their activities. Certainly, the automotive sector is responsible for huge consumption of resources from the ground and harmful emissions releases. Therefore, car-makers are looking for effective systems to quantifying the environmental impact of their products, while balancing economic revenues. In this context, it is worthwhile to consider instruments as Life Cycle Assessment (LCA) and Life Cycle Cost (LCC) to quantify the environmental and economic load over the whole life cycle of the product. The main goals of the project is to verify applicability of these two methodologies as a supporting tool to identify the main sustainability hotspots in the product life cycle and guide strategy development, to provide elements for production decisions. This analysis is rooted within automotive context: a LCA combined with eLCC have been applied comparing a standard and innovative part. The lightweighting strategy has been selected to enhance sustainability purposes. The lightweight effect of composite as a replacement of heavy-metal, have been analyzed and extended beyond company perimeter with focus on EoL outlooks. Furthermore the dynamic behaviors of components operations along vehicle use have been investigated. To address the impact on resources and emissions concerns, the following impact categories have been selected: i) Global Warming Potential, ii) Abiotic Depletion Potential, Resource Depletion Water and Primary Energy Demand. Results are presented in such a way to calculate the total impact score, for each design solutions, differentiating each life cycle phase's contribution. Results indicate that the elimination of the heavy metallic component with the substitution of a lower plastic material causes a halving of the averageof the impact percentage; on the contrary, composite worsen the effect on water depletion. From eLCC, it emerges that materials acquisition and fuel quantity for vehicle use represent the greatest impact. The trade-off between materials cost and manufacturing depends on where the consistent costs saving during use manage to counterbalance the material cost increase of the innovative solution. To conclude, the environmental and economic analyses have identified the main product sustainable hot-spots, confirming that an accurate and exhaustive analysis can provide a more comprehensive vision on product design decisions implication toward economic and environmental effects. Indeed the continuous investigation of innovative materials can spawn good ideas for reflection on not only regarding their potential technical features but also their possible management in other applications and field. In this sense, it is worthwhile to look beyond the company analysis perimeter and attempt to balance the macro-levels of the whole life cycle.

SDEWES2018.0089

Life Cycle Assessment of Solar Heating and Cooling Systems: the Tool "Elisa"

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Abstract

Solar heating and cooling (SHC) systems play an important role in the achievement of the energy and climate European goals, by reducing the use of fossil fuels and the related environmental impacts of buildings.

Experts in the field of SHC usually investigate the advantages of using these systems in different climatic conditions in substitution of conventional technologies, focusing on the operation step. However, to correctly assess the real benefits due to the installation of SHC technologies, their life cycle energy and environmental impacts should be estimated (from the raw materials supply to the end-of-life) and compared with the benefits obtained during operation. A useful methodology to assess resource use, energy and environmental burdens related to the full life cycle of products and services is the Life Cycle Assessment (LCA).

However, the development of a complete LCA can be difficult and time-consuming particularly for no-LCA experts, discouraging them in the inclusion of the life cycle perspective in their assessments.

To overcome this limit, the paper presents "ELISA - Environmental Life-cycle Impacts of Solar Air-conditioning systems", a user-friendly simplified tool for estimating the potential life cycle energy and environmental benefits/impacts of the solar technologies in different geographic contexts compared to conventional plants.

The tool can be applied for the comparison of SHC and conventional systems, also equipped with photovoltaic panels, and allows for calculating the following indices:

global warming potential, global energy requirement, energy payback time, global warming potential payback time and energy return ratio.

"ELISA" can be used by researchers, designers, and decision-makers to introduce the life cycle thinking approach in the design phase of the SHC systems, taking into account environmental considerations in the field of the solar cooling and heating systems (PV or solar thermally driven systems).

The tool was developed within the Task 53 "New generation solar cooling & heating systems (PV or solar thermally driven systems)" of the International Energy Agency.

SDEWES2018.0110

River Classification Index (RCI): a Tool for Preliminary River Quality Assessment Considering River Restoration Aspects

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Abstract

River restoration is an innovative vision of water resources conservation, searching for a more compatible balance between human needs and the dynamics of nature, and offering effective and more sustainable opportunities to face the flood risk problems. This new concept seeks to promote the improvement of the river ecosystem quality, recovering as much as possible the environmental, functional and structural characteristics existing before unbalanced anthropic interferences. Thus, aiming to create a tool capable to indicate the environmental status of a watershed and to quantitatively assess the effects of river restoration actions, supporting decision making, the River Classification Index (RCI) was developed in this work.

RCI is based on river restoration tools currently in use in Australia, Spain, Italy and Brazil, and some concepts have been recently presented in the Urban River Restoration Index (URRIx). Its formula is composed of two indicators representing "connectivities" and "riverbanks condition", in a weighted summation of effects. To operationalize indicators of distinct natures and units, they are normalized into the same scale of variation, ranging from 0 to 1: the more critical areas are associated with lower values of the index.

The proposed methodology was applied and tested in two case studies, rural and urban, both of them in Brazil. These cases refer to the Sesmaria River, a heterogeneous rural watershed with pasture, some preserved areas and a city near its outfall, located between São Paulo and Rio de Janeiro states and Dona Eugenia River, an urban floodable watershed at the Rio de Janeiro metropolitan area.

The obtained results allowed to compare critical areas, as well as to simulate the effects of different measures applied to the watersheds, departing from the diagnosis of the current situation. FCI for Dona Eugenia river watershed showed a value of 0.59 in the current situation, ranging from 0.53, when a dam was designed upstream, for flood control purposes, to 0.63, if an urban river restoration project has taken place. The RCI results for Sesmaria River basin started with 0.56 and showed a great possibility of environmental recovery, reaching 0.93 if a river restoration approach was adopted. These cases showed that RCI was sensible and responded consistently to the introduced variations, enabling this tool as a decision making support capable of hierarchizing different design alternatives.

SDEWES2018.0130

Method to Assess Mining Impacts in Tropical Forest Areas Using Satellite Images

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Abstract

Companies in the mining sector are constantly looking for new areas to exploit so as to meet rising demand. This is especially true in Brazil, where mining products currently account for 21% by value of exports. The objective of this study was to assess the impact of mining in tropical forest areas, by analyzing the vegetation index, calculated by analysis of Landsat satellite images. The tool was applied to a bauxite mining operation at the Port of Trombetas, in the municipality of Oriximiná, Pará, Brazil. The evaluations covered the steps of opening the area, mining operation and decommissioning, in the period from 1996 to 2017. Applying the proposed method, the results showed that the decommissioning process was 100% efficient as measured by the vegetation index, which in the restored areas reached values higher than those of the original native forest. However, the replanting process needs to take into account the timing of the successional forest stage, since primary and secondary species have different needs for survival and development.

SDEWES2018.0160

Life-Cycle Assessment Applied to Future Scenarios of Electricity Generation in Sicily

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Abstract

Fighting global warming and increasing the energy security are some of the most relevant objectives of the European energy policy. Thus, defining potential low carbon pathways for the energy sector is of paramount importance in order to identify strategies with the lowest impact on climate. This paper presents an overview of environmental assessment of future electricity scenarios in Sicily (Italy), for 2020 and 2030, characterized by a high exploitation of renewable energy sources. Authors apply the Life Cycle Assessment methodology, according to the standard of the ISO 14040 series, in order to evaluate the environmental impacts of electricity generation in the future scenarios in comparison to the current situation and to quantify the achievable potential environmental improvements. Due to the increase of electricity generation through renewable sources, results show a significant reduction of the non-renewable primary energy consumption. Among all the examined environmental categories, nearly all present a decrease of the impacts. Then, the results highlight that, although an increase in penetration of technologies fed by renewable energy can improve the eco-profile of the electricity generation, it is not possible to reduce all the environmental impact categories.

Data and results of this study are site – specific and updated on current and on future Sicily electricity mix generation that can be used as knowledge base in the definition of low carbon energy strategies in Sicily. Moreover, they can support the decision makers and the local authorities in an "ex ante" evaluation of the energy and climate strategies aimed at reducing the CO_2 emissions.

SDEWES2018.0605

Benchmarking Sustainable Urban Systems at the Interface of the Landside and Seaside: Port Cities and Coastal Settlements on Islands

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Abstract

Port cities and coastal settlements on islands take place as interfaces between linkages on the landside and seaside. Such positioning can provide valuable options for renewable energy, transport modes and water resources. Similarly, an integrated view on the energy, water and environment systems of these cities can provide additional insight on multiple opportunities beyond those that are applicable to other cities. This paper extends the benchmarking of Mediterranean port cities based on the Sustainable Development of Energy, Water and Environment Systems Index based on a new sample of 11 port cities and coastal settlements on islands. The new sample includes the city of Palermo that has a Sustainable Energy Action Plan with the target of reducing CO2 emissions by 22% by the year 2020. Other cities have adopted similar plans and/or provided recent monitoring reports. The benchmarking results are utilized to identify best practices among the analysed cities, including best practices that can transform the landside and seaside interface into advantages for more sustainable urban systems. The best practices are discussed in the context of such initiatives as the Greening the Islands Initiative and projects in the Greening the Islands Observatory as well as the ten action points and seven key areas of the Smart Islands Declaration. The research work has ramifications for supporting the integration of systems in port cities and coastal settlements on islands based on local opportunities and the provision of strategies that could be used to improve index performance.

Waste and wastewater treatment and reuse 3

SDEWES2018.0189

Impovement of Management of Plastic Waste from Small Household Appliances ?

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Abstract

Small appliances (or small household appliances) are part of our daily life, the supply of materials and especially plastics to meet the demand of its production is growing. Thus, this leads to the growth of e-wastes as these appliances were disposed of f, which can lead to crucial end of life issues such as recycling or landfilling. The recycling of materials is highly appreciated under the circumstances of circular economy, thus the plants nowadays are requested to treat large amount of wastes to meet the European recycling goals. In France, 39.4 thousand tons of plastics from disposed small appliances were generated in 2016. The request of recycling rate keeps increasing and the present sorting technologies shows limits to achieve higher recycling efficiencies.

The objective of this paper is to propose an improved sorting technology for plastics. Since sorting of materials is the most important step in recycling process, it will contribute to the following steps such as regeneration of materials and at last the recycling rate. The proposed method, froth flotation, depends on the surface wettability of plastics to reach a better sorting, experiments conducted using this method have proven its potential for plastic mixture sorting. A material flow analysis (MFA) of plastic from EoL small appliances in France is conducted.

In this study, we selected major plastics families in small appliances which are Acrylonitrile-butadiene-styrene (ABS), high impact polystyrene (HIPS), and polypropylene (PP). Current plastic sorting technologies have color or density limits that influence the sorting rates. For small appliances, ABS, HIPS and PP with fillers have similar densities and about 41% of them are dark colored. The proposed method; Froth flotation; using surface agents to perform the selective separation is less impacted by color or density and thus provide high sorting rates. Hence, this sorting method was included in a MFA study of plastics from EoL small appliances to assess its effectiveness.

Using the selected agent in the froth flotation, the sorting rates of ABS & HIPS plastics of dark colors and similar densities were improved by 30. This leads to the improvement of the recycling rate of plastic wastes. Our results can offer an insight of the potential benefit of using this new sorting technique in plastic waste management of small appliances and other EoL products with plastic materials.

SDEWES2018.0200

Analysis of Tailings Dam Failures Using a Risks Serie Methodology

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Abstract

Mining is one of the main sectors of the global economy, supplying raw materials for many industrial activities. The mining industry typically produces large amounts of tailings, commonly stored in ponds behind dams, which have a great potential for damage in case of rupture. From 1915 to 2017, a total of 297 tailings dams failed in the world. Risks Serie analysis is a qualitative tool that allows assessing the sequence of possible events and consequently control of the risks through preventive and mitigating measures. The tool was applied to analyze how the rupture of a dam by liquefaction can be triggered, and what the consequences of this break. In this way, the tool can be used as evidence in the establishment of processes, assist environmental agencies in the application of penalties, and help dams owners better understand how the financial health of the business will be impacted by these failures.

SDEWES2018.0275

Modeling and Design of Membrane Integrated Processes for HCl and Metals Recovery from Pickling Solutions

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Abstract

Hydrochloric acid pickling is a common practice in steel manufacturing industry. It is widely used as a chemical pre-treatment method for cleaning metal surfaces before other surface treatments. During the pickling process, acid attacks metal oxides on the metallic surface, thus dissolving them in the pickling bath. Thus, the efficiency of the pickling liquor decreases due to the accumulation of metal salts and the consumption of free acid in solution. Continuous regeneration of pickling solutions enhances pickling rate and process performance, but also minimises industrial waste water disposal and chemicals consumption. The recovery and recycling process of valuable substances (e.g. acid, metals and water) can be accomplished by coupling diffusion dialysis (DD) and membrane distillation (MD) technologies.

The process can be described in this way: more than 80% of the free acid exiting from the pickling bath is recovered and separated from the metals by passing through a selective anionic exchange membrane (in the DD), then, its concentration is properly increased by evaporation of water through a hydrophobic membrane (in the MD) in order to be recycled in the pickling bath. The metal salts trapped in the outlet solution from the diffusion dialysis are recovered as valuable products in a reactive precipitation unit by precipitating iron hydroxide as a solid phase and keeping zinc salt in the solution.

In the present work, a steady state process simulator for the integrated process has been developed, aiming at the performance analysis and prediction of a small pilot-scale unit to be installed and operated within a hot-dip galvanizing plant. A parametric analysis of the model is performed varying hydrochloric acid and iron concentration in the pickling tank. In this way, refilling with fresh acid, as done in the normal operations, is avoided and operations are carried out under the optimal working conditions.

SDEWES2018.0440

Municipal Solid Waste Incineration in a Packed Bed: a Comprehensive Modeling Study with Experimental Validation

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Abstract

Global municipal solid waste (MSW) generation is 1.3 billion tons in 2010 and is projected to reach 2.2 and 4.2 billion tons by 2025 and 2050, respectively. MSW incineration has many advantages over landfills, e.g., recovering energy, avoiding CH_4 release and mitigating soil and water contamination due to the otherwise landfilled MSW. Therefore, MSW incineration gains a lot of attention worldwide. By 2015, over 255 million tons of MSW are incinerated annually in about 1180 MSW incineration plants with power generation around the world. In the same year, about 80 million tons of MSW are combusted in 220 MSW incinerators in China, corresponding to 32.7% of total MSW disposal in this year in China. Packed bed combustion technology is widely used for MSW incineration, in which the solid wastes are packed on the grate at the bottom of the incinerator, the primary air enters from beneath the grate and the majority of the wastes are burned out in the packed bed on the grate. As a result, an in-depth understanding of MSW combustion in the packed bed plays a vital role in design and optimization of a MSW incinerator and the overall performance of a MSW-to-energy plant in terms of environmental impacts and efficiency.

In this paper, a comprehensive mathematical model is developed to simulate MSW incineration in a packed bed, which is validated by a detailed experimental study of MSW incineration in a given packed bed. For the given feedstock and primary flow rate, only one reaction front propagating from the bed surface to the grate is observed due to the abundant oxygen availability in the MSW bed, while the second reaction (i.e., char burnout) front propagating upwards from the grate may not exist in the test case. After experimental validation, the model is used for a parametric study. It is found that large particles tend to delay the ignition but promote the burnout of the packed bed and low operation pressures can remarkably delay the burnout of the packed bed. The model is expected to be used in computational fluid dynamics simulation of an industrial MSW incinerator for problem shooting and operation optimization.

SDEWES2018.0462

Analyzing Relationship Between Wastewater Utility and Civil Society Stakeholders: First Evidence from Two Cases

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Abstract

Wastewater utilities are pivotal players in the path toward sustainability. In order to understand why they may prioritize the adoption of a given innovative solution, the paper focuses on two factors, i.e. regulatory obligations and pressures for change coming from civil society. Two cases are studied to compare the community's concerns about the effects of wastewater management and the standards that objectivize the same effects. After coding it, collected information is analyzed to find out possible rank reversals between community and regulator's priorities. The preliminary results show incongruences between the contingent pressures received from the community and the impact that is substantiated by regulations, and identify factors that could explain the tendency of utilities to overperform along selected dimensions, i.e. to reduce negative effects beyond standards.

SDEWES2018.0530

Recyclable and Integrated Aqueous Two-Phase System (ATPS) for Cost-Effective Recovery of Biotechnological Products

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Abstract

Aqueous two-phase system (ATPS) is a simple and low cost technique for bioseparation. One form of ATPS known as ATPS extractive bioconversion integrates the production and recovery of biomolecules into a single step process. A comparative study of the extractive bioconversion of gamma-cyclodextrin (γ-CD) from solvable starch with Bacillus cereus (B. cereus) cyclodextrin glycosyltransferase (CGTase) using the recyclable ethylene oxide-propylene oxide (EOPO)/potassium phosphate and polyethylene glycol (PEG)/potassium phosphate ATPS systems was carried out. Under the optimized ATPS condition for both systems, higher yield of γ-CD was obtained in the top phase of the EOPO/potassium phosphates ATPS (1.60 mg/mL) in a shorter time (i.e. 1 h bioconversion process) than that of the EOPO/potassium phosphate (0.87 mg/mL) in 2 h bioconversion process. CGTase, on the other hand, was partitioned into the salt-rich bottom phase and there was a gradual loss of CGTase activity with successive removal of the top phase. A larger decrease in the relative enzyme activity was noted in the EOPO/phosphates ATPS. Purification of CGTase from B. cereus using the PEG/potassium phosphate aqueous two phase flotation (ATPF) system was also demonstrated. Under an optimal condition of 18.0% (w/w) PEG8000, 7.0% (w/w) potassium phosphate, volume ratio (VR) of 3.0, 80 min nitrogen flotation time at a flow rate of 5 L/min and 20% (w/w) crude load (pH 7), CGTase was successfully purified with a yield of 97% and a purification factor of 22 whereby both values are higher compared to ATPS with purification factor of 16.0 and a yield of 70%. The strength and limitation of the each ATPS systems will be discussed.

Storage 2

SDEWES2018.0081

Experimental Investigation of a High Temperature Latent TES with Novel Fin Geometry

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Abstract

Thermal energy storage (TES) has been identified as a key technology for efficient industrial processes, sustainable housing and, most importantly, the robust inclusion of renewable energy sources. Therefor different storage types are currently under investigation. At the Institute for Energy Systems and Thermodynamics (IET) at the TU Wien, a high temperature latent TES with novel fin geometry was designed and erected.

Using the enthalpy of fusion, the phase change of storage material, the storage capacity of thermal energy storages can be increased, compared to sensible storage technologies. This advantage refers especially to small changes in temperature, which is interesting for steam power plants, including concentrated solar power plants and other industrial waste heat processes.

The latent TES uses 280kg of sodium nitrate as storage material which melts at 306°C. Storage temperatures up to 350°C are possible. With the test rig, the storage capacity and the dynamic behaviour of this TES type is investigated. Furthermore the storage is equipped with more than 40 thermocouples, so the melting behaviour can be examined exactly and compared to simulations, which were done for exactly that fin geometry. The geometry was newly developed in order to increase the heat flow rate in the storage material and reverse and to decrease the charging- and discharging time.

For an efficient integration of TES in existing energy systems, benchmarking data for different storage types are needed. This paper represents a contribution to the development and comparability of novel TES systems.

SDEWES2018.0230

Experimental Investigation of a Moving-Bed Heat Storage Thermochemical Reactor

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Abstract

This study investigates a moving-bed thermochemical reactor with hydrated salt and humid air flow, suitable for building heating applications. A well-instrumented reactor prototype, developed to produce a heating power up to 1 kW, allowed analysing the functioning of the reactor. The $SrBr_2.H_2O$ / $SrBr_2.6H_2O$ pair was used and allowed reaching reactor temperatures up to 41°C and specific heating powers of 1.7 to 4.6 kW/m^3 of reactor bed. Once the thermal steady state was reached, the temperature was homogeneous throughout the bed. This study highlights the impact of the air humidity at the reactor inlet on the reactor performances and shows the feasibility of continuous thermochemical heat storage in a moving bed reactor with hydrated salt. Finally, this study highlighted the advantages and limitations of moving bed reactors for thermochemical storage applications.

SDEWES2018.0235

Distribution and Diffusion Investigation of Organic Phase Change Material in Nano-Confinement by Molecular Dynamics Simulation

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Abstract

Phase change materials (PCMs) are widely used in sustainable energy systems such as the waste heat utilization systems, solar storage systems and building. In recent years, concerning the low thermal conductivity of organic phase change materials (PCMs), the method of inserting high conductivity nano materials have been received much attentions. As extremely forms of carbon, the carbon nanotubes (CNTs), the graphene nanoplatelets (GNPs) and the carbon porous own excellent properties like ultrahigh surface area and high thermal conductivity, which are very suitable for enhancing thermal performance of PCMs. Since there exists plenty of nano scale space in these nano materials, it forms the nano-confinement for PCMs after combined by capillarity. In nano-confinement, interfacial interaction and scale effect play important roles which would change some properties of PCMs. Many researches about these kind of topics have been reported. However, the studies about the capillarity, the heat transfer and the phase transition in nano-confinement are still in controversy with divergent opinions of researchers getting from their experimental and numerical data. A vision in molecular scale is needed. Trying to investigate the behavior of organic PCM in nano-confinement, molecular dynamics (MD) simulation is performed in this paper. Different kind of confinement are constructed: one-dimensional (30, 30) CNT with diameter of 4.068 nm, two-dimensional graphene layers with slit of 4 nm. The distribution and diffusion properties of n-eicosane in confinement are analyzed. The one- and two- dimensional carbon materials are confirmed to be wettable by n-eicosane as shown by the results. The stable distribution of n-eicosane is to form monolayer near the wall when there is free surface exist. It also reveals that the mobility of molecules in nano-confinement is promoted significantly by the interaction of wall. Especially, the monolayer formed by active molecules can get a self-diffusion as high as 77.76×10-10 m2/s, which is 18.6 times value of the bulk. Furthermore, the phase change during heating process, which is different between confined phase and bulk phase, can be detected according to the variation of self-diffusion coefficient. It can be indicated that the thermal performance of PCM would be improved in nano-confinement, which shows great potential for sustainable applications in energy storage, electronic devices and building.

SDEWES2018.0528

An Economic Feasibility Study of Large-Scale Power-to-Gas Energy Storage

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Abstract

Development of renewable energy sources generates demand for industrial energy storage systems. Recent developments in production and use of reversible solid oxide cells (ReSOC) make them a suitable candidate for energy storage [1].

The ReSOCs can convert H_2O and CO_2 to syngas (H_2 and CO) and O_2 molecules using electricity. In the reverse process electricity is generated and syngas is converted to H_2O and CO_2. This enables the ReSOC system to store electricity as gas at times with cheap renewable electricity and provide electricity at times with high demand and high prices. A partial internal catalytic conversion of the produced syngas to CH_4, and in reverse operation mode a partial reforming of the CH_4, makes it is possible to obtain a system round trip efficiency (electricity-methane-electricity) of up to 80 % [2,3]. Coupled with cheap subsurface gas storage this potentially enables truly large-scale electricity storage [4].

This study provides an economic analysis of the potential of integration of a ReSOC energy storage system into an existing energy infrastructure. A 100 MW ReSOC energy storage is analyzed using Aspen Plus software. We provide a list of the main components of the storage system with their technical characteristics and investment costs. Further, an economic feasibility study is conducted using historic and forecasted electricity prices for the Western Denmark (DK1) price area. A few scenarios (different sets of hourly electricity, fuel and heat prices) are examined to determine optimal conditions of the storage operation including the storage capacity limited by the size of CH_4 and CO_2 caverns for subsurface gas storage. Finally, the results are briefly compared with other electricity storage technologies.

SDEWES2018.0639

Experimental Benchmark for High Temperature Latent Storage Modeling

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Abstract

Along with the renewed interest in the concentrated solar power technology, high temperature latent energy storage becomes a very popular scientific topic. The industrial application of high temperature phase change materials (PCM) is mostly limited by low achievable heat transfer rates - consequence of the low heat transfer coefficients of PCMs. Two most popular solutions to this problem are improving the effective thermal conductivity of PCM by mixing salts with different materials and improving the heat exchanger geometry. One of the most important steps in the second approach is the accurate simulation of melting and solidification processes. Consequently, a number of different numerical models is developed and published recently. Such models are usually validated by existing experimental date of low temperature melting problems and/or by temperature data from experiments developed for that specific application. While the most important aspect of the simulation is the location of the melting front, there is a lack of experimental data of melting/solidification front propagation that can be used for model validation. In this paper, an experimental setup for acquisition of melting front during sodium nitrate melting is presented. The experimental data is compared with the simulated data obtained with the model based on enthalpy-porosity approach. The first results suggest that popular enthalpy porosity method is inadequate in cases where the melt front is moving perpendicular to free surface.

Energy and Environment 2

SDEWES2018.0124

A Review on Research Achievements in a Field of Black Carbon Exploration

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Abstract

Black carbon (BC) is one of the main air pollutants and has been extensively researched in the latest years. This paper represents outcomes of a review on the 161 studies and findings available in the field of BC matter that have been made so far by different authors from all over the world. The studies were acquired from the online database Web of Science. An index table was designed to enable a deep insight into BC exploration while indicating and addressing the identified characterisation factors of the studies. Furthermore, a statistical analysis was carried out with the aim of assessing how studying of BC aerosols varies, for example in different worldwide regions, considering location of the study, correlations with environmental challenges, and topics within the BC discussed, e.g. health effects of BC.

SDEWES2018.0570

Issues of COP21 - Renewable Energy, One of the Ways to Mitigate Climate Change World

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Abstract

Droughts, floods, disease, migration, food shortages, possible conflicts, etc. : The second part of the fifth report of the Intergovernmental Panel on Climate Change (IPCC) lists the already observable impacts of climate change.

According to the text of the IPCC, the result of a huge work of reading and compilation of twelve thousand scientific publications, climate change has had in recent decades impacts "on all continents and oceans", mainly on natural systems.

In many regions, changes in precipitation patterns and the melting of snow and glaciers have modified hydraulic systems, "affecting water resources in quantity and quality."

Climate change has also impacted more "negative" as positive on food production (wheat and corn). The range, the number of individuals or migratory practices of many marine and terrestrial species have changed.

Many findings that push the IPCC to further darken a little more perspectives on the effects of global warming in the twenty-first century. "The likelihood of severe impacts, widespread and irreversible increases with the intensification of global warming," warns the IPCC

It is within this context that we present the findings and the risks involved, then we present what international climate policies developed in response to scientific reports and then present what are the reasons for such political inertia ?

SDEWES2018.0585

Evaluation of Energy and Environmental Challenges of Installing Cold Ironing – Case Study Port of Koper

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Abstract

The European Union has ambitious goals for reducing energy consumption and greenhouse gas emissions. In this context results from already implemented projects have clearly demonstrated, how much can be done in reducing the energy intensity of manufacturing processes through energy efficiency and sustainable modifications of production processes. However, it is important to emphasize that further improvements are possible and vitally important, especially in relation to mobility, for which new approaches are necessary. Switch from auxiliary engines to shore electricity or cold ironing, have a significant potential to reduce local emissions of greenhouse gases and operating noise level. Additionally, providing electricity for ships at berth may represent a new business opportunity for ports or electricity utilities and can be source of additional revenue.

This paper presents a systematic evaluation of achievements and future development challenges related with the development of sustainable port infrastructure at the Port of Koper. Special emphasis was placed on future strategies related with selection of appropriate solution for the shore to ship power supply and includes comprehensive evaluation of available technologies. Based on the performed analysis it is clear that electrification has a potential to unlock significant energy and environmental benefits which presents a growing challenge for future development of the port infrastructure. However, it has to be aware that cold ironing requires significant modification of the existing electricity grid, which is a very expensive and relatively long lasting process. For the selected cases, sensitivity analysis has been performed in order to determine how different values of an independent variable (investment costs, selling price of electricity to vessels at berth, sold amount of electricity and wholesale electricity price) impact a simple payback period of the investment in cold ironing at the Port of Koper under a given set of assumptions.

SDEWES2018.0588

Climate Change Impact Assessment on the Miho-River Basin Based on a Load Duration Curve

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Abstract

Main purpose of this paper is to suggest and evaluate an operational method of assessing the potential impact of CC on hydrologic components and water quality at the regional scale. Future runoff of the Miho-river basin was simulated using HSPF model based on high resolution Regional Circulation Model (RCM) and Representative Concentration Pathway (RCP) scenario operated by the Korea Meteorological Administration. In particular Sleuth model was applied to simulate a land use change in future 30 years. The flow duration curve (FDC) was estimated and compared with observed data. And daily runoff data simulated was used to evaluate the effect of CC scenario on the flow and water quality changes. The flow duration curve showed that the mean average low flow increased while the average wet and normal flow decreased under the climate change scenario. Applying FDC, a load duration curve (LDF) was made and used for evaluating the effect of CC scenario on a river water quality.

SDEWES2018.0609

Performance and Emission Characteristics of a Micro Gas Turbine Fueled with Bioalcohol/Jet-A Blends

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Abstract

Gas turbine engines, such as those used in aircraft and stationary power generators, use large amounts of petroleum-based fuel and cause significant air pollution. Due to the growing interest in renewable fuels related to the environmental impact and governmental regulations in the article uses fuels based alcoholes which can be produced by fermentation, or thermochemical conversion of biomass (bio-propanol, bio-butanol, bio-pentanol). Experimental results done on the Turbojet Engine with a static thurst of 140N at 120,000 RPM. This kind of engines are used for aircraft propulsion modeling, but may also be used for military purposes include UAV. .The performance characteristics including the thrust, thrust-specific fuel consumption, and the emission properties, such as thrust-specific emission indices of CO and NOx, were measured for the different blends and compared with those obtained for Jet A over a range of throttle settings. The operational range of engine rotational speed was shifted downwards with the addition of alcohole components. There was no uniform emission change trend for all alcohol additives. This study demonstrates that biofuels may serve as viable supplements to petroleum-based fuels.

SDEWES2018.0618

Greenhouse Gas Mitigation Policy and its Impact on Slovenian Industry

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Abstract

Reducing Greenhouse Gas (GHG) emissions and the transition to a low carbon economy are without doubt the highest priorities of energy and environmental policies and strategies in many developed countries. Industry has an important impact on both sides, significantly contributing to the GDP, while emitting GHG, also significantly. Industry accounts for over 30% of the final energy consumed in the world and more than 40% of all GHG emissions (taking into account discharges in the use and conversion of fuels, process discharges and indirect discharges of electricity and district heating). Mitigation policy measures in general are dictated mainly by environmental and energy policies, energy supply requirements and business interests of various actors. In this research paper, the GHG emissions trends in Slovenian industry are presented, taking into account discharges in the use and conversion of fuels and process discharges. Furthermore, GHG mitigation policy targeting industrial sector is reviewed and discussed, to highlight the existing and proposed measures and industrial practices. The results of the research work show that GHG emissions in Slovenian industry sector are decreasing, mostly due to energy efficiency measures and process improvements that can mostly be attributed to the individual initiatives of energy intensive industries. The transition to a low-carbon economy is somewhat of a great development opportunity and challenge for the Slovenian industry, since it is necessary to reduce costs, while achieving the best environmental, economic and technological effects. Mitigation policy and corresponding GHG reduction measures should be implemented in a way to support the interdependent aspects of such transition.

Alternative fuels and innovative energy conversion processes

SDEWES2018.0265

Experimental Assessment of a Direct Methanol Fuel Cells Model

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Abstract

Although direct methanol fuel cells (DMFCs) represent a good alternative to hydrogen fuel cells, several issues still exist which currently prevent the appearance of DMFCs in the market. These are related to: low activity of electrocatalysts for the methanol oxidation reaction, methanol crossover, CO2 generation at anode and water imbalance. In this paper, a comprehensive numerical model is developed using ASPEN PLUS V9 and validated against experimental results. To calibrate the coefficients of the thermo-chemical formulation and to validate the model, a complementary experimental analysis, using the same operating conditions, is carried out in our lab at DIMA. Despite experimental testing and verification are the proper way to overcome these drawbacks, the availability of reliable simulation tools can help in addressing the most promising technical solution, thus reducing the efforts in terms of costs and time. Experimental data and numerical predictions agree well everywhere but in the region of low current density. The comparisons show that the increase of temperature improves DMFC performance. The influence of crossover in cell performance when varying the temperature was also assessed against literature data showing that, even if methanol crossover current density increases too. However, growth in crossover is not sufficient to suppress the increase in the cell performance and then the overall effect of the better cell activity prevails over crossover. Present results are compared with literature data on similar configurations with encouraging agreement.

SDEWES2018.0455

North Adriatic Offshore Gas Facility Reutilisation for Blue Energy System

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Abstract

In European Union strategic documents, one of the development sectors within the blue economy that promotes the exploitation of the sea potential has been identified as blue energy, while exploitation of hydrocarbons is among other critical sectors. European energy initiatives recognize the importance of blue energy and encourage its research and development. The exploitation of hydrocarbons on some of the gas exploitation fields in the Adriatic is entering the final phase, followed by the gradual decommissioning of the production platforms and their removal. Decommissioning usually has an adverse effect on the environment aside from its economic intensity. Objective of the paper was to explore the possibilities of existing infrastructure utilisation for blue energy. Paper deals with preliminary assessment of natural gas offshore infrastructure applicability for various blue energy options such as the wind power for electricity generation along with hydrogen, methane or ammonia production and other uses to reduce waste, energy consumption and CO_2 emissions. Methodology used included data gathering from 19 offshore gas facilities regarding wind potential. Preliminary results show that there are possibilities for feasible blue energy utilisation, especially from the environmental point of view. To investigate economic feasibility of decommission delay, detailed data gathering of wind potential should be done at specific heights along with load capacity of the gas platforms.

SDEWES2018.0496

Integration of Solid Oxide Electrolysis-Based Power-to-Methane with Oxy-Fuel Combustion

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Abstract

The storage of excess or low-cost electricity in the form of synthetic gas using power-to-gas technologies is a promising approach to enable high shares of renewables in power generation and reduce the fuel carbon content. The use of synthetic methane as a storage medium would be facilitated by the existing natural gas distribution and storage infrastructure, and end-use equipment. However, the efficiency of standalone, low-temperature electrolysis-based power-to-methane (PtM) processes is presently limited. As a way of enhancing the potential of this technology to support the decarbonization of energy systems, this study investigates a high-temperature electrolysis and catalytic methanation-based PtM process and its material/thermal integration with an oxyfuel combustion cycle, to co-generate synthetic methane, heat and power. The system incorporates heat, oxygen, carbon dioxide (CO_2) and water recycling. The energy and exergy-based performance of the compound assembly and its sub-systems is investigated using an overpotential-based electrochemical model. Depending on electrolysis operating temperature and pressure, overall energy and exergy efficiency vary from 77–80.6% and 65.6–68.5%, respectively. The system avoids substantial CO_2 emissions by eliminating air separation for oxygen production, and recycling of oxyfuel CO_2 and both heat and water recuperated from hydrogenation processes.

SDEWES2018.0550

Application of Liquefied Natural Gas in Road Traffic in the Republic of Croatia

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Abstract

Over the years, liquefied natural gas (LNG) increasingly enters as fuel in road and maritime traffic, and it is slowly planning to enter railroad traffic as well. This trend was inspired by the state administrations of some countries, international organizations that, in liquefied natural gas, see a more cost-effective and environmentally-friendly alternative to diesel. A number of infrastructural projects have been launched around the world, which represent the basis for the widespread use of LNG in different transport branches. This paper presents the use of LNG as a fuel, possible application and security of use along with economic and ecological aspects. In addition, it shows the current state of use of LNG in transport in Europe and the current state of projects related to the development of using LNG in transport in the Republic of Croatia. The LNG filling stations for road vehicles are described, the economic aspects of their introduction has been analyzed along with the standards applicable to the road vehicles. Paper brings comparative analysis of heavy truck diesel vehicles and LNG vehicles. It was concluded that using LNG as propellant fuel has many advantages over the use of other conventional fuels. Despite the higher prices of the road vehicles that are using LNG, in the long run they are more affordable than the classic diesel vehicles. In addition to cost-effectiveness, the use of road vehicles that are using LNG reduces CO_2 emissions and supports the strategic goals of the European Union as well as the energy goals of the Republic of Croatia. The problem of Croatian road transport system for LNG is the lack of infrastructure for filling the vehicles. Therefore, certain types of incentives clearly need to be defined in order to facilitate the introduction of LNG into the market.

SDEWES2018.0578

Injection and Combustion Analysis of Rapeseed Oil Methyl Ester (Rme) as Fuel in a Diesel Engine

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Abstract

As fossil fuel reserves are depleted daily the interest in alternative fuels increases. Biodiesel is one of the best candidates in this class and its use is expanding rapidly throughout the world.

Numerous researchers have been investigating how biodiesel affects combustion and pollutant formation of diesel engines and there is general agreement that its combustion characteristics are similar to those of standard diesel fuel, except for a shorter ignition delay, a higher ignition temperature, and greater ignition pressure and peak heat release. Engine power output is similar with both fuels. As regards emissions, reductions in particulate matter (PM) and carbon monoxide (CO) and increases in nitrogen oxides (NOx) are described with most biodiesel blends. The latter is referred to as the 'biodiesel NOx effect'. A large part of researchers who explored the effect of biodiesel did so in mechanical injection engines. The first organised studies by the National Renewable Energy Laboratory (NERL) to measure biodiesel speed of sound and establish its impact on injection timing in diesel engines dates back to 2003 and states that the primary mechanism by which biodiesel increases NOx emissions is by an inadvertent advance in the start of injection timing, caused by a higher bulk modulus and viscosity. However, subsequent studies show that NOx emissions also increase in biodiesel-fuelled common rail engines and that in some cases they actually decrease in engines with mechanically controlled fuel injection systems. This implies that the biodiesel NOx effect cannot be explained solely by differences in compressibility and remains an open question. In particular, further studies are needed to better analyse the effect of injection timing, injection pressure and combustion characteristics on NOx emissions in biodiesel fed engines.

The present study provides a contribution to the discussion in this field by analysing the injection and combustion characteristics of rapeseed methyl ester in a diesel engine equipped with a pump-line-nozzle (PLN) injection system.

In particular experimental results are shown demonstrating that in PNL injection plant the injection advance due to biodiesel higher bulk modulus is less than that theoretically expected. This is explained through a detailed analysis of injection pressure trend showing how pressure in the injection pipe just before injection (i.e. residual pressure) is lower with biodiesel than that with diesel.

SDEWES2018.0625

Studying the Potential for Innovative Interactions Between Water, Energy and Soil for Sustainable Cities in France: Overview of the Wise Cities Project

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Abstract

Water management has a key role to play in improving the urban environment in future cities. Beyond water-related impacts, new water management approaches take water-energy-soil (WES) interactions into account. However, the benefits of such novel approaches remain to be estimated and the best way to go about it is unknown at this time. This raises the question:

How can such new water management approaches contribute to sustainable urban development?

To answer this question, determining the contribution of new experiences built on WES nexus innovations to sustainable urban environment, including broader environmental, social and economic dimensions, is paramount. Furthermore, there is no clear consensus on the way to design the possible water management strategies. Should such strategies rely on centralized or decentralized infrastructure and/or governance? Should low tech, robust strategies be preferred over newer high tech, “smart” ones? And how should these two dimensions be combined?

The Water-energy-soil Interactions for a future Sustainable Environment in Cities (WISE Cities) research program aims to provide answers to these questions, with the goal of accompanying cities in their implementation of new water management strategies that best contribute to their overall sustainability.

This multidisciplinary project will concentrate on two main case cities in France, Paris and Nantes, and two temporal horizons: 2030 and 2050. The most credible WES technologies and practices will be selected and gathered into several key-concepts, some of which require a more detailed assessment through experimentation or observation. This selection will feed the development of a dozen different credible and coherent deployment scenarios associating different key-concepts virtually projected in urban and climate projections for 2030 and 2050. The transitional issues of these scenarios will be analyzed and their environmental and socio-economic impacts will be assessed through modeling.

The proposed presentation will provide an overview of the WISE Cities research program which will bring together social and physical scientists from seven different French research institutions over the next five years or longer.

Energy Policy

SDEWES2018.0042

Transition Pathways Optimization Methodology Through Energyplan Software for Energy Scenarios to 2050

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Abstract

The planning of an energy system with high penetration of renewables is becoming increasingly important to face environmental and energy security issues. Policy makers need tools capable of simulating energy systems over the years to develop effective energy policies. Within bottom-up energy system modelling, two different approaches exist: one optimizes the energy mix of a selected future year, while a second optimizes the transition pathway between the current baseline and a future year. Markal/TIMES and OSeMOSYS are examples of valid modelling tools for both approaches. Due to computational issues, these models usually adopt low time resolutions and follow a time slice approach. The latter approximation is questionable given that renewables are intermittent and storage, stationary and in electric vehicles, is needed. To overcome the accuracy issue we have developed a methodology based on a multi-objective evolutionary algorithm and the EnergyPLAN software, which allows for year by year simulations with an hourly time-step.

This paper proposes a methodology for creating transition pathways using EnergyPLAN and applies it to the Italian energy system. The simulation model is composed by a sequence of yearly EnergyPLAN simulations. The model includes a cost decrease of the technologies year by year and the need of power capacity due to the decommissioning of old plants. The model provides a Pareto front of cost-optimal solutions for any target value of cumulative emissions reduction, up to the maximum CO_2 abatement potential, and the total cumulated costs related to each solution.

SDEWES2018.0129

Optimizing Roadmaps Under Learning Rate Effects

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Abstract

1-. Motivation and objectives.

The transformations of the energy system to one of low or zero GHG emissions, has been tackled from the point of view of policy by the design of Roadmaps.

Some are derived minimizing a cost function for the whole energy system, that is claimed to represent the competitive markets behaviour - the IEA. Others derive paths in an ad-hoc way, under some restrictions and optimization considerations, adjusting the total energy generated to a predefined demand path - Irena. Both approaches are 'demand-led', and do not account for Learning Rate (LR) effects. Some kind of exploration on its likely consequences is warranted.

2-. Methodology.

The research starts by deriving theoretical optimal paths for technologies with LR effects. First, the conventional cost minimization criterion of the total path of future investments discounted at present value is considered. An analytical optimal solution for the deployment of capacity in all future periods is derived, and is shown to be valid only under some restrictive conditions. Then, an alternative solution for the optimum path is suggested, based on numerical methods.

Several generalizations are explored: two or more regions, and energy sources, the rate of depreciation and the life span of the investments, and other capital expenditures, and Balance of System Costs.

3-. Main results.

The Irena and IEA, PV RMs are considered. The first group of results refers to the solution methodology proposed. It is shown, that despite showing considerable variability, it is close to the analytical solution. This implies, that provided actual capacity deployment tracks the general trend of the optimum road map, slight departures from this trend do not have a significant impact on the final criterion. This is a relevant, since in practice, it would almost be impossible to follow closely any predefined path.

As for the discount rate, it is found that large values penalize the early deployment of energies with high LR, the advice being to use low values, closer to the social discount rates. High LR values yield a lower deployment at early stages under a simple cost minimization criterion: this highlights the need to consider broader criteria like the LCOE.

4-. Conclusions.

The methodology and results presented are a partial equilibrium 'caeteris-paribus' approach, and several relevant results have already been uncovered. The way forward to cover a more realistic case has also been laid out, with relevant generalizations considered.

SDEWES2018.0195

The Role of Intermediaries in Energy Transition: a Case for Ireland's First Generation of Sustainable Energy Communities

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Abstract

Ireland is undertaking a process of reducing carbon emissions and dependence on fossil fuels by transitioning to low carbon technologies. This is a challenging undertaking requiring a multi-pronged solution. However, the challenge of transitioning from fossil fuel to sustainable energy system is not merely a technological problem but a wider societal issue. Ireland's National Energy White paper (December, 2015) and the National Mitigation plan (June, 2017) emphasise the key role of citizens and communities in meeting energy targets and leading the nation into a low carbon future. The Sustainable Energy Authority of Ireland (SEAI) is Ireland's national energy authority with the mission of transforming Ireland into a society based on sustainable energy structures, technologies and practices. One of the main pillars of its thrust to meet this challenging objective is the Sustainable Energy Communities (SEC) Programme. Since 2015, SEAI has been successful in motivating over 100 communities to participate in the SEC network. In this context, the main aim of this paper is to assess the role of intermediaries in Ireland's community energy transition. This paper will look at analysing the intermediary roles in communities in Ireland using Strategic Niche Management theory. The paper presents research based on empirical evidence gathered through semi-structured interviews conducted with 12 energy intermediaries in Ireland working to diffuse community energy. The intermediaries were interviewed on their role, impact, relationship with communities, policy makers, government affiliation and networking building. The initial findings indicate that intermediaries use a variety of ways to diffuse knowledge for community projects; however, the institutional framework surrounding intermediaries' play a big role. The findings also stress the importance of networking and intermediary actors/organisations in providing support for community energy as well as helping diffuse learning and information between various community initiatives. This research also paves the way to a more detailed study of intermediary roles in SEC development in Ireland

SDEWES2018.0547

From Value Stacking to Tool Stacking in Renewable Gas Regulation

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Abstract

The Danish biogas production has developed remarkably, since it was agreed to improve the conditions for biogas production with the Energy Agreement back in 2012.

The number of new biogas plants has increased substantially and most new plants have chosen to upgrade biogas into biomethane. Consequently, total spending on biogas support has increased significantly while at the same time costs for other renewables such as wind and solar power have decreased.

Biogas based on manure and other waste products can contribute with several green values and reduce CO2-emissions, not only by replacing fossil fuels, but also by converting methane and dinitrogenoxid (laughing gas) into the less climate harming gas CO2. Furthermore, biogas and in particular biomethane is storable to a much higher degree, than e.g. wind- and solar power. Biomethane can therefore provide flexibility to the energy system under the right regulatory system or provide a cheaper 2G transport fuel compared to biodiesel. By stacking all these values, we find socio economic arguments for higher support levels for biogas, than for e.g. wind power.

Looking at the newest Energy Agreement, regulators still seem to be willing to pay extra for renewable gas; however, with more focus on cost efficiency it is likely that support levels will be reduced with time.

In this paper, we investigate how future regulation could steer renewable gas production in various directions taking all values of biogas into account: 1. CO2-reduction, 2. Renewable gas production, 3. Power system and flexibility options or 4. Green transport fuels opportunities.

We use a mixed integer-programming model to explore the optimal choices for input and biogas application mixes, following the private economic perspective of the biogas producers under various regulatory schemes. In the scenarios are regulatory tools stacked to target several values at the same time, however, with various focus. Results are evaluated with regard to private economic performance, CO2-reduction, renewable gas production and flexibility.

We find no real incentives for a plant to act as a flexibility provider under current regulation and current electricity prices. We further find that governmental support costs can be reduced, if electricity- and excess heat taxes are reduced simultaneously. When regulation is targeting CO2-reduction, may total support cost increase, while total biogas production may be reduced, however, the biogas production may become more sustainable.

SDEWES2018.0595

Assessing Employment Impacts of Japan's Renewable Energy Target for 2030

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Abstract

The Japanese government published the Long-term Energy Supply and Demand Outlook based on the Strategic Energy Plan. The Outlook shows power generation mix in fiscal year 2030, where renewable energy accounts for 22 to 24 percent of the total power supply. While the power generation mix is decided considering energy security, energy cost and climate change, the employment impacts of an increase in renewable power generation have not been examined.

The aim of the present study is to assess employment impacts of renewable energy deployment in Japan based on the Outlook for 2030, focusing on the potential to increase job creation in rural areas.

The present study uses a renewable energy-focused input-output (REFIO) model, which is built on the latest Japanese input-output table by disaggregating the original sectors and adding new sectors related to renewable power generation technologies. The REFIO model can capture the direct and indirect employment impacts of the deployment of renewable power generation technologies and can analyze how many and what kinds of jobs are created or lost considering a decrease in conventional technologies.

The assessment reveals that direct and indirect employment opportunities related to power generation in 2030 are about 8% greater than those in 2016. The expansion of renewable power generation technologies increase domestic employment in biomass fuel production-related sectors, maintenance sectors of PV and wind power generation facilities, and non-life insurance sector and so on. On the contrary, reducing fossil-fired power generation technologies leads to the decrease in overseas employment associated with fossil fuel production as well as domestic employment in the road freight transport sector, wholesale trade sector, building repair sector and so on. Besides such changes in employment among sectors, it is important that employment opportunities occur in a wider range of areas due to the shift from centralized large-scale to decentralized small-scale power plants. It should be noted that the Outlook has a large uncertainty about the restart of nuclear power plants in the future, and whether the restart proceeds as planned significantly affects the change in employment opportunities.

In conclusion, the present study quantifies the potential employment impacts of the change in power generation mix according to the Outlook for 2030. Detailed information on the sectoral and regional changes in employment opportunities contributes to energy policy making in the future.

SDEWES2018.0610

Energy Transition Scenarios in the Extended Neoclassical Model of Economic Growth Under the Eroei Uncertainty

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Abstract

This paper explores the consequences of declining quantity and quality of extractable fossil fuels and relatively low EROEI (Energy Returned on Energy Invested) of renewable energy technology for the continued economic growth.

The main objective is to assess the future performance of the global economic system undergoing an energy transition represented by the neoclassical model of economic growth extended with the energy sector. EROEI is used as a varied parameter, representing uncertainty expressed in the literature.

The Neoclassical growth model was enriched by feedback and non-linearity based on its extension with the energy sector using system dynamics as a specific modeling technique for this purpose. Capital services in the Cobb-Douglas production function necessitate energy use. Energy is supplied by the energy sector composed from the stocks of fossil fuels resource, fossil fuels producing capital and renewable energy producing capital. The model simulation comprises the time period of 1965-2065. Model is able to correctly reproduce historical time series for its main variables: GDP, energy production etc. for the last 50 years.

Model scenarios with renewable technology quality of EROEI15) which permits gradual replacement of fossil fuels without the necessity of upfront investment. Model scenarios dealing with the renewable energy technology with EROEI

Model sketch macroeconomic consequences of various energy transition scenarios based on the renewable energy technology quality and used investment strategy. Dynamics of the standard neoclassical growth model is enriched by the addition of the energy sector, which makes model path dependent with respect to the renewable energy investment.

Poster session 1

SDEWES2018.0012

Emissions Reduction on Thermal Power Turbines Firing CO2-Rich Natural Gas: Technical and Economical Evaluation Applied to a Floating Production Storage and Offloading (FPso) Unit

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Abstract

The offshore processing of associated CO_2 rich (44%mol) natural gas from ultra-deepwater fields imposes a challenge to minimize greenhouse gas emissions while having constraints in area and weight for the design of floating production units. Supersonic separator was considered for pre-conditioning the gas as to water and hydrocarbon dew-points and for partial CO_2 abatement (%CO_2 ≈ 20%), according to Arinelli et al. (2017) studies. Pre-treated natural gas was investigated for power generation using gas turbines GE LM2500+G4, appropriated for offshore production. To reduce emissions and to increase oil production, a post-combustion process for carbon capture and storage (CCS) using CO_2 as fluid for enhanced oil recovery was applied and optimized. Estimation for CAPEX/OPEX and footprint impacts due to CO_2 emissions reduction were developed. Four combined cycle (CC) configurations and a simple gas cycle were evaluated by comparing footprint, weight, power, efficiency and CO_2 emissions, considering a regulation of 100 MW production limit. The software Aspen HYSYS was used to simulate the process and the gas turbine was designed as a combination of compressor, combustion reactor and expander, which was validated by comparing with its manufacturer specifications. The CC with two gas turbines, an once-through heat recovery steam generator and a steam turbine (CC 2:1:1) presented the most favorable results for the parameters evaluated, having 53% efficiency and 476.8 gCO_2/kWh emissions. Despite similar weight, the CC 2:1:1 has ~10% increase in footprint comparing to the simple cycle, which, in its turn, presents low efficiency (39.4%) and high CO_2 emissions (641 gCO_2/kWh). Both configurations were coupled to a CCS plant, including a chemical absorption (MDEA/piperazine) unit to treat exhaust gas and a sequence of intercooled stages of compression. The process was validated by substantially reducing CO_2 emissions for both CC 2:1:1 and simple cycle, reaching 241 gCO_2/kWh and 250.5 gCO_2/kWh, respectively. The CC 2:1:1 with CCS plant presented higher efficiency (43%), lower weight and potential lower footprint when comparing to simple cycle with CCS plant. The results highlight the advantages of using CC for offshore power generation, especially for CO_2 rich natural gas processing in ultra-deepwater fields, without having significant impacts on footprint utilization. The use of a coupled CCS plant is emphasized for EOR purposes or for scenarios with carbon taxation.

SDEWES2018.0013

Development of a Reliable and Fast Method to Measure NOx Emissions in Vehicles

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Abstract

NOx emissions in vehicles are currently only controlled through the homologation process. Vehicles in EU-28 are also subject to PTI (Periodic Technical Inspection), yet NOx is not among the pollutants currently being controlled. This is why there is currently a lack of tools to reliably assess and control real NOx emissions of vehicles. In order to fill this knowledge gap, a new method is proposed for measuring NOx in PTIs currently carried out on registered vehicles. The method is a simple, quick, inexpensive, representative and accurate way to measure NOx emissions. Moreover, it is carried out under static conditions, so no simulation test bench or similar are required. It has been developed and validated at a PTI Spanish station, in order to check repeatability and representativity. Repeatability has been checked according to the standard deviation of NOx measurements, and representativity has been checked using the correlation between NOx emissions and % engine load, using a p-value lower than 0,01.

Finally, the method has been compared to a different NOx measurement technique based on the test bench and an ASM 20-50 cycle. The good representativity and repeatability of the new method achieved shows that it could be a useful tool to be applied in PTI for detecting and controlling high NOx emission vehicles.

SDEWES2018.0014

Is Driving Slower a Synonymous of Less Polluting Emissions? The Case of Diesel Vehicles

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Abstract

Diesel vehicles are more efficient but also more polluting than petrol ones. From last times the sales of Diesel has grown up and nowadays around the half of the European passenger car fleet is Diesel. Besides due to vehicle emission tests don´t represent the real conditions, as it was recently published with the Dieselgate scandal, the NOx real emission are several times higher than in homologation conditions and as consequence the renovation of old Diesel vehicles for cleaner ones during last years has not contributed to reduce NOx levels.

This fact has contributed to increase the NOx air levels in cities with the harmful associated risks for human health. To control NOx emission levels some cities have had to adopt urgent measures such as traffic speed reduction. This kind of measures can be positive to save fuel and reduce CO_2 emissions but CO_2 and NOx emissions are not strictly linked.

In this paper, an own methodology to assess the effectivity of reduce speed limit from 90 km/h to 70 km/h in city belts is presented. Two market representative Diesel vehicles have been monitored through real driving conditions collecting information from Electronic Control Unit (ECU) to a cloud server through the vehicle OBD II port. The parameters registered are:air flow, rpm, speed, engine load, fuel consumption and CO_2 emissions. Moreover through these data other relevant variables such as exhaust gas recirculation level and NOx emissions have been calculated.

As a result it has been demonstrated how speed and emissions (CO_2, NOx) are not strictly connected, and other parameters like the gear used and the engine load are more relevant because they directly influence in the Exhaust Gas Recirculate (EGR) valve operation. This valve controls the exhaust gases recirculating levels and as consequence the combustion chamber temperature and the NOx generation. Regarding the title question it has been demonstrated that in the speed range of the experiment a slower driving does not means to pollute less.

SDEWES2018.0018

Energy and Environmental Life Cycle Assessment of Asphalt Pavements: a Scenario Analysis for Urban Roads

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Abstract

This paper aims at calculating the life-cycle energy and the environmental impacts pertaining to roads management, including materials production, transportation, construction, maintenance, and rehabilitation.

A life-cycle approach is applied to assess energy and environmental impacts of a typical Italian urban road, according to the ISO 14040 series. In more detail, the Authors assess the energy and environmental profile of different optimized scenarios of bituminous mixtures. The aim of scenario analysis is to identify the less impacting scenario from an energy and environmental point of view. For each analysed scenario, the contribution of each life-cycle step to the total impacts and the energy and environmental hotspots are identified in order to define suitable options for improvement.

Results show that the pavement scenarios, characterized by the use of recycled materials, involves lower energy and environmental impacts, due to the saving of virgin raw materials and avoided impacts for disposal.

SDEWES2018.0022

Energy Scenarios for Cities to Achieve Environmental Commitments

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Abstract

In 2008 European Commission launched the Covenant of Mayors (CoM) program with the aim to encourage that local governments worked to reduce at least a 20 % their greenhouse gases emissions before 2020. To renew their commitments to further horizons, Covenant of Mayors program proposed that signatories should reduce at least a 40 % their greenhouse gas emissions before 2030. To accomplish with this target, signatories must submit a Sustainable Energy Action Plan (SEAP) where the key actions to achieve the targets must be explained.

In this paper an own methodology to support those signatories that are updating their action plans is presented. By means of a top-down approach the measures that must be applied to accomplish these new targets are defined. This method assesses different variables such as final energy consumption by sector, electricity emissions, population growing or urban mobility modes. Main results are presented in Sankey diagrams to preview the possible energy scenarios to 2030.

As case study is presented the situation for the city of Zaragoza. In 2011 Zaragoza local government signed the Covenant of Majors agreement with the commitment to reduce at least 21 % its CO2 emissions for 2020. In a Business As Usual (BAU) scenario, Zaragoza will achieve a 25 % of CO2 emissions reduction in 2020 but extra efforts must be done to achieve new target further than 2020. These efforts are explained in the Climate Change, Air Quality and Health Strategy of Zaragoza (ECAZ 3.0) that was published in June 2018.

SDEWES2018.0072

Hybrid Systems Approach Supporting Management to Improve Coral Reef Resilience and Provision of Ecosystem Services in a Changing Climate

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Abstract

A realistic perception of the linkage between ecosystem services and the level of human well-being, particularly under changing climate conditions, can provide decision and policy makers with a holistic understanding of key factors influencing the planning process. An integrated, participatory, risk framework for assessing health and resilience of coral reefs, and the consequential impacts on human well-being in Port Resolution on Tanna Island Vanuatu, are presented. To link an assessment of the health and resilience of coral reefs with human well-being, it is essential to follow a structured process employing techniques capable of dealing with different challenges including: 1) uncertain future climate conditions and changing human activities; 2) impacts from trans-discipline variables; and 3) systems subject to spatial variability. To accommodate these considerations, the applied framework followed a sequential process of coupling Structural Analysis (SA) and Bayesian Network (BN) techniques. First, structural analysis was used to describe the whole system, to quantify the relevance of relationships between system components, and to provide the initial graphical presentation of system variables. This graph was calibrated through a series of multidisciplinary expert workshops and used to create the conceptual BN model. Next, BN modelling was conducted using both qualitative and quantitative analysis stages. Relationships between variables described by the conceptual BN were captured as a causal structure defined using an influence diagram known as Directed Acyclic Graph (DAG). The strength of influence between these variables was quantified in a Conditional Probability Table (CPT). The probabilities in the CPTs represent the quantitative part of BN modelling. The CPTs were populated based on evidence extracted from literature, parametrized data obtained from the region, and tacit knowledge elicited from experts through a series of workshops using multiple climate change scenarios. Sensitivity and scenario analyses were completed to assess the impacts of different variables under different probable scenarios on the target node in the final step. The results predict the vulnerability of the coral reefs system under various climate change scenarios as well as the related impacts to the local economy and residents well-being.

SDEWES2018.0075

A Soft Traffic Management Approach for Achieving Environmentally Sustainable and Economically Viable Outcomes: an Australian Case Study

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Abstract

Transport infrastructural strain is a pressuring issue for the urbanised world due to the increasing demand for public transport. It is critical to developing an environmentally sustainable and economically viable efficient traffic network to relieve traffic pressure (i.e., traffic congestion, transport infrastructure investment needs). Transport operators, planners and policymakers are constantly searching for low-cost solutions to such transport issues. The objective of this research is to propose a "Soft Traffic Management (STM)" concept to proactively analyse the traffic impact of transport planning strategy before implementation. This study investigates the effectiveness of a STM for easing the traffic pressure by carrying out a pilot research project on the proposed South East Busway extension in Logan City, Australia, by employing a stepwise process consisting of multi-stages analysis, stakeholder-based and modelling approaches. The results indicate that the extended busway can significantly relieve traffic congestion. In addition, the proposed strategy has significant positive impacts on the environment as it aims to reduce air pollution and fuel consumption as well as to improve the safety and efficiency of the whole transport system. This study confirms the effects of STM on how to use existing infrastructure more efficiently and defer future transport infrastructure investments.

SDEWES2018.0079

Life Cycle Energy Sustainability Assessment: an Expanded Framework for Energy Technologies

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Abstract

Life Cycle sustainability assessment is one of the most relevant tools delving in sustainability science, based currently on the triple bottom line idea, that is identified in the use of the three tools of Life Cycle Assessment (LCA), Life Cycle Costing (LCC) and Social Life Cycle Assessment (S-LCA). The methodology is structured on international regulations and is currently being applied to a wide set of products and systems.

However, when targeting specifically energy technologies with this methodology some specific issues need to be taken in consideration before applying tout court the standard LCSA methodology. Energy systems – in particular those where fluid streams are used – have an understanding depth that cannot be fully currently investigated with the available tools, thus having only a partial understanding of the problem.

This paper proposes to develop an extended framework for LCSA introducing two additional stages to the theory, to address the limits highlighted in the previous paragraphs: Constructal law (CL) inspired analysis of the energy design of the system and life cycle exergy analysis (EA) of the system and its life cycle. The two additional stages aim to introduce the concepts of energy efficient design inspired by natural systems (CL) and the necessity to explore technological obsolesce throughout the life cycle of the product (EA).

A fully developed case study (a biomass boiler) is proposed, described in all five stages of the extended Life Cycle Energy Sustainability Assessment: LCA, LCC, S-LCA, CL, EA, highlighting both the quantitative results related to each section and the strengths and limits of the methodology, while stressing the potential applications as e.g. decision support tool and support to the design of energy system.

The results highlight different and optimized designs for the boiler through a Constructal law based analysis and several hot-spots throughout different stages of the life cycle, ranging from the production stage of steel for most environmental indicators in LCA to the cooking stage for the exergy analysis. Relevant positive impacts are traced also in the S-LCA point of view during both the use and production step.

The methodology is inter-disciplinary and fully integrated, being applicable either at the design stage or as a decision support tool in the choice between alternative energy systems.

SDEWES2018.0102

Renewable Energy Integration Through Power-to-Heat/power-to-Cool System in the Old City of Dubrovnik

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Abstract

The integration of renewable energy sources (RES), such as wind and solar power, indicate for additional flexibility in the power system, according to their intermittency. RES will play a major role in reducing the overall green house gas emissions, being a part of a global response to the threat of climate change. Previous study done for the power system of the Dubrovnik region has shown the ability of the system to achieve self-sufficiency being 100 % renewable. The results of the study shown that the self-sufficient power system could be achieved adding the additional energy storages or additional sources of flexibility in the system. Heat sector stands out with the great potential in decarbonisation since it has a large share in the final energy consumption. Previous studies have shown that the power-to-heat technologies may contribute to heat sector decarbonisation as well as the integration of RES if they are sufficiently flexible. They are also shown to have good effects on the system costs. In this work we selected one of the power-to-heat/power-to-cool technologies to satisfy heating and cooling demand of the Old City of Dubrovnik. Technology used in this work is a seawater source heat pump. The Old City is selected because of its specific situation. Most of the people in Dubrovnik use air condition to supply their heating and cooling demand which can also be defined as a power-to-heat/power-to-cool technology. The problem with the Old City is that a large number of the outdoor units in not well approved by UNESCO since the Old City is the UNESCO World Heritage Centre. This work will provide a solution by replacing all air conditions and implementing the seawater source heat pump that could cover all the heating and cooling demand. We had to collect the data on overall heating and cooling demands in order to calculate the capacity of the heat pump. The analysis showed that the seawater source heat pump will provide additional flexibility in the system and improve the utilization of RES into the power system.

SDEWES2018.0120

Consumer Perspective on Sustainable Energy Policy Development: Case of Slovenia

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Abstract

Abstract. Environmental protection and sustainable development has become an unavoidable trend in many sectors including energy industry. Energy policy and energy industry development are strongly correlated with economics of energy sources, environmental issues and socio-political issues. However energy policy is many times to distant from public and public is not even aware of crucial energy related projects in progress. This paper therefore presents findings on public perception on energy policy and evaluates public awareness and public integration into energy policy related issues and decision making, evaluates preferences for its development and assesses sustainability of current Slovenian energy policy. The most important findings are that public should be better informed as well as integrated stronger in energy policy decision making and that public is willing to pay 5.8 % more for environmentally friendly energy. Public also demands greater focus on social and environmental dimension instead of focusing solely on economics and technic.

SDEWES2018.0175

Water Dynamics as a Preceding Driver for Risk Prevention and Urban Planning Guidelines

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Abstract

Land use changes in urban agglomerations alter the water cycle, aggravating floods and putting assets and people at risk. City growth processes, when not properly conducted, may induce imbalances related to ignoring natural constraints. A method for considering the water dynamics in the planning process is proposed and applied to the city of Paraty, in Brazil. Mathematical modeling tools are used and combined with indicators to assess flood risks. A past functional reference is adopted as a concept image and lessons are learned by comparison with the current situation. Future scenarios are prospected, considering that “water spaces” should be part of an open space system, helping to define guidelines to rule built-up spaces according to water dynamics. In practical terms, urban drainage assumes the function of balancing built and natural environments needs by providing safe areas from flooding, as well as space and passage to floods, while preserving environmental values.

SDEWES2018.0183

Energy and Environmental Impact Evaluation of a Forced Circulation Solar Water Heating System Equipped with an Evacuated Solar Tube Collector Under the Mediterranean Climate Conditions

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Abstract

In the present work the energy evaluation and the assessment of the environmental impact for a forced circulation solar water heating system under the Mediterranean climate condition is carried out. The system is equipped with a heat pipe evacuated tube collector having an aperture area of 1.476 m^2. Recorded data obtained from this trial-field installation refers to time intervals of 1-min. They are used to perform the energy evaluation, the economic evaluation, and the environmental impact assessment of the system during a 12-months period. The obtained results include monthly values of the useful heat gain from the solar collector, delivered energy, collector efficiency, system efficiency, avoided CO_2 emissions, and the payback period. Also, the annual energy balance of the studied system obtained from the calculations gives a clear view regarding the useful heat gain and the losses.

SDEWES2018.0269

Life Cycle Assessment of Methyl Bromide Production Process

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Abstract

Methyl bromide is an effective and useful insecticide. Its primary advantage is its ability to penetrate quickly into materials at room temperature & pressure. It also desorbs and dissipates rapidly from material. However exposure to it causes serious health related issues. It is also one of the ozone depleting substances. As per the Montreal Protocol, countries are required to reduce its use for non-quarantine practice. Nowadays it is primarily used for container fumigation purposes. In view of this, it is important to find the environmental impact associated with methyl bromide production process using Life cycle assessment (LCA) studies. The inventory data needed to evaluate the impacts was obtained from M/s Intech Pharma Pvt Ltd, located at Dhargal, Goa, India. Two approaches viz. cradle-to-gate and gate-to-gate approach has been used for the LCA of methyl bromide production. Simapro software was used to compute the results of Life Cycle Impact Assessment (LCIA). Results of the gate to gate approach revealed that production of methyl bromide has a significant effect on the non-renewable energy reserves, global warning and respirable inorganics. From the results of Cradle to Gate approach it is noted that production of methyl bromide has a significant impact on ozone layer depletion, mineral extraction, non-carcinogens, land occupation, aquatic eutrophication and aquatic ecotoxicity.

SDEWES2018.0281

Energy, CO2, Ethanol and Water Assessments of a High-Scale Sugar-Cane Based Biorefinery: Prelude of a Full Carbon Capture Scenario

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Abstract

The sugarcane industry is one of the most important economic activities in Brazil, producing sugar and ethanol for all over the world. The aim of this work is to assess energy and water consumption, CO_2 emissions and ethanol production to evaluate economic feasibility of a high-scale sugarcane based biorefinery in Brazil in order to evaluate plant adaptability to a plausible scenario of full carbon capture and sequestration so that the integrated complex biorefinery-plantation could become a sustainable carbon withdrawer from the atmosphere. The present study is performed with the aid of a professional software for rigorous mass and energy balances simulation to achieve process data for plant technical and economic analysis. The only source of energy in the process is the combustion of sugarcane bagasse, which provides steam for the distillery and for power generation. The production of ethanol from the fermentation of glucose also produces CO_2 which is released directly into the atmosphere, as the CO_2 from combustion, increasing global warming. Results show that, for a capacity of 1,000 ton/h of sugarcane processed, this process emits 16 ton of CO_2 per ton of ethanol produced and 0.7 ton of CO_2 per ton of sugarcane consumed, with net water consumption of 3600 m^3/h as make-up water to replace blowdown and evaporation losses in the cooling tower. The co-generation system generates 320 MW of net power for exportation as electricity. The economic analysis indicates a fixed capital investment of 910 MMUSD and a positive Net Present Value of 378 MMUSD, considering ethanol produced and electricity from co-generation as revenues at an annual discount rate of 10%.

SDEWES2018.0330

Utilization of the Farm Organic Waste by Using an Anaerobic Co-Digestion Process

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Abstract

The process of anaerobic digestion is used for treating varies types of organic waste such as food waste, animal excrements, organic fraction of municipal solid waste, yard waste, and as the final result of the process biogas and compost are acquired. Obtained biogas can be used as a source of renewable energy. The quantity of acquired biogas depends on various factors such as the elemental composition of the substrate, inhibitors, hydraulic retention time, etc. The main objective of this paper is to optimize biogas production on a cow farm by using multicriteria optimization. As substrates in anaerobic co-digestion on the are used: cow excrements, whey, maize silage and organic fraction of the municipal solid waste. Occasionally, in the process of biogas production, glycerin is added as an accelerant. The idea of this paper was to optimize the mixing ratio of the substrates with an aim to enhance biogas production and treat all generated amount of cow excrements generated on the farm and organic fraction of municipal solid waste generated in the nearby town. The boundary conditions set for the multicriteria optimization was the C / N ratio in the range of 15 to 30 and the amount of available organic substrates. The verification of the developed model was done on the case study of the cow farm, and the optimal mix of different organic substrates was determined, as well as the biogas yield.

SDEWES2018.0340

Simulation of Flow Characteristics of Particles in a Drum Cooler

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Abstract

In order to improve the waste heat recovery efficiency of metallized pellets, the flow characteristics of metallized pellets was investigated. The soft sphere model and discrete element method (DEM) were used to investigate the effects of dip angle, rotating velocity, filling rate, and the number of heat exchanger tube. The calculated values of the motion of particles showed good agreement with the corresponding available experimental data. The motion of particles in the drum cooler with heat exchanger tube was compared with that in the drum cooler without heat exchanger tube. The axial velocity, the total velocity, the mixed standard deviation, the contact number between particles and wall, and the contact number of particles were studied. The results showed that, the flow characteristics of particles in the two kinds of drum cooler is quite different, and the severe motion of particles in the drum cooler with heat exchanger tube is more conducive to heat transfer and waste heat recovery.

SDEWES2018.0355

Modeling and Simulation of Series/ Parallel Hybrid Electric Vehicle（SPHEV）

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Abstract

Hybrid Electric Vehicles referred as HEV whose vehicle driving system composed of two or more single drive system. The vehicle driving torque provide by a single drive system alone or together based on actual vehicle driving state.HEV has two kinds of advantages compared with the traditional vehicle and electrical vehicle. The first one is that energy consumption and emissions performance of HEV are better than that of the internal combustion engine powered vehicles. The second one is that HEV's mileage is far more than that of pure electric vehicles. At present, HEV is one of the directions of development of automotive. Because of its energy saving and low emission, HEV have become a focus of research and development of automobile, and have already begun to be commercialized.

A brief analysis of the structure and function of Series/Parallel Hybrid Electric Vehicle(HEV) are discussed in this thesis. Then Established the simulation models of key components, Vehicle and controller by using Matlab/Simulink software and built the off-line simulation platform. The modeling method and algorithm of the hybrid system key components model are analyzed, and the control strategy of the whole vehicle is designed according to the working mode. Furthermore, the dynamic performance and fuel economy of the vehicle under the NEDC driving cycle were simulated and calculated.

The performance of the HEV model can meet the functional requirements by verification both on off-line simulation and real-time simulation. The dynamic and economic performance index can achieve the desired effect. And the methods could provide a reference for research on modeling and simulation of other hybrid systems.

SDEWES2018.0389

Bim Technology for Low Enthalpy Geothermal Energy Plants

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Abstract

This paper proves the effectiveness of using Building Information Modeling (BIM) as a strategy for the realization of combined heating and cooling plants coupled to geothermal heat exchangers.

Geothermal energy can be considered as an alternative energy source for heating and cooling needs, using the ground as a renewable energy source. The authors propose to reuse the freezing probes, employed for the Artificial Ground Freezing (AGF) of two tunnels of the underground station in Piazza Municipio in Napoli, as geothermal heat exchangers. In this way, additional drilling costs related to traditional geothermal probes can be avoided.

. The present system allows to obtain high energy efficiency and low environmental impact, according to the European energy policy, which aims to achieve at least 27% of the energy production from renewable sources by 2030. The experimental set-up has been realized in the construction site of the underground station of Piazza Municipio in Napoli in southern Italy.

The galleries, about 40 m long, mainly involve two layers of land, made of Neapolitan yellow tuff and pozzolana. Each freezing probe is installed within a horizontal hole of 114 mm diameter created in the ground. The stability of this hole is ensured by the presence of a stainless-steel tube. The freezing probe consist of two coaxial tubes: the external one is made of stainless steel and has a diameter of 76 mm and a closed bottom. Its external surface is in contact with a cement mortar. The internal tube is made of copper and has an open bottom and a diameter of 28 mm. Through the flanges, the probes are connected to a high-density polyethylene pipe and to a horizontal wall-mounted geothermal collector, which allows fluid flow coming from the distribution circuit to the inner tube of the freezing probe. The probes are connected to a power unit, called “Energy box”, containing a heat pump, an inertial storage, two expansion tanks and measurement instruments.

In addition, a management and monitoring process has been developed to increase the efficiency of the system. A system providing the programmed maintenance of the components of the plant has also been developed.

SDEWES2018.0392

Environmental and Energy Performances of a Newly Installed Dish-Stirling CSP Based in Palermo

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Abstract

SourceURL:file:///E:/Dropbox/sdewes%202018/articolo%20LCA%20concentratore%20solare%20OK/Dish%20stirling%20LCA_rev_finale.docx In the last decade there has been a significant increase globally in solar based electricity production, like those produced from Concentrating Solar Power (CSP) plants. One of the most efficient CSP technologies today is the Dish-Stirling characterized by an efficiency greater than 30%, which may become highly competitive by 2030 according to the International Energy Agency. On one hand, the Dish-Stirling is responsible for high environmental impacts, caused during its production and installation due to their energy consumption and use of energy intensive raw material. On the other hand, no direct emissions are released during its use phase. However, only a careful analysis of the entire life cycle can give a clear representation of all generated impacts. Therefore, we present a preliminary Life Cycle Assessment of a grid-connected Dish-Stirling concentrator with nominal power of 33 kW located in Palermo, Sicily. The study has been implemented according to the international standards of series ISO 14040/44 (2006) with the aim to evaluate the Dish-Stirling's eco-profile, which in a first step identifies the main energy flows and environmental impacts of the use-phase. The importance of the study is underlined by the fact the here considered CSP is the first connected to national grid. As first step primary data on the energy production in the use phase have been collected and a comparison in terms of CO_2ewith the normal energy grid showed that we are able to save 89% of the total CO_2e emissions.

SDEWES2018.0452

Suitability of Some Existing Damage Indexes for Regulating Contracts Between Curators of Museums and HVAC Maintenance and Management Companies

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Abstract

Heating, Ventilating and Air-Conditioning (HVAC) systems in museums are called to properly control important microclimate parameters, not only for visitors' wellbeing, but mostly for works of art preservation. Accordingly, in case of interruptions occurring to HVAC systems, due to maintenance interventions or drawbacks, it is essential to guarantee the shortest possible period of disservice to which possible damages for the works of art are related.

In this regard the aim of this work is to introduce a protocol to follow to support curators in regulate the stipulation of contracts with external companies for a more effective management and maintenance of the HVAC systems in order to preserve the works of art, by integrating into the contracts economic penalties related to the system's disservice period.

The feasibility of this new procedure has been checked by means of a case study involved the "Museo Regionale" of Palermo (Italy).

SDEWES2018.0476

Evaluating Monetary Benefits from Reducing Indoor Pollution in North Delhi Region

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Abstract

Air pollution which is a byproduct of urbanization and growth causes severe damage to health status of individuals due to which a considerable amount of their earnings are spent on medical expenditure. Delhi has experienced highest level of air pollution recently and North Delhi region being the region signifying old commercial set up of Delhi, the paper therefore involves the study of health impact due to air pollution in North Delhi area. The main objective of the study is to determine the factors which affect health of individuals captured by number of days an individual falls sick. The research methodology is based on a household production function model involving survey of households within a distance of half a kilometer from monitoring stations for air pollution of CPCB (Central Pollution Control Board) and DPCC (Delhi Pollution Control Committee) situated at Pitampura, Delhi College of Engineering (DCE) and Civil Lines during the winter season. The study constructs various indices like Indoor Pollution Index, Nutrition Index, Health Stock Index, Awareness Index and Habit Index. The impact and correlation of these indices on the health status of individual measured by number of sick days is then evaluated to assess the relationship of these variables with health status. Further, the study suggests that the indoor air pollution, outdoor pollution, poor status of health stock along with the nutrition status of an individual are some of the crucial factors determining the sick days of an individual. By controlling these variables an individual can reduce the number of sick days and hence attain monetary benefits. This study plays a substantial role in propagating consciousness about indoor air pollution across the individuals living in Delhi identifying the significance and factors determining indoor pollution in North region of Delhi. The results of this study holds a great significance in terms policy implications for government to provide cleaner energy in form of clean source for cooking to households who are the end users, reducing the lobbying of vested group in provision of LPG gas, pipelines etc.

SDEWES2018.0478

Analyzing Sustainability of Energy in 3 E Framework: Ecological, Economic and Environmental Perspective

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Abstract

Energy is an essential ingredient and a prerequisite for economic growth and development of a nation. However, energy is a natural resource whose consumption is limited by its fundamental nature of existence. The use of energy is constrained not only as natural resources but also from the perspective of economic system which requires more and more energy for economic growth. Excessive rise in population and growing middle class in most of the developing countries further exerts more pressure on energy demand. Energy in its conventional form has also been a substantial source of emissions of carbon- di-oxide, leading to the current challenge of climate change. As a result use of energy is constrained not only as its ecological existence of natural resource but also environmental challenge. The primary objective of the paper is to rationalize the energy transition towards renewable energy sources from both ecological and environmental concerns and further evaluate the sustainability of renewable energy sources itself. The paper explores the issues and concerns related to sustainability of energy use by over viewing theories of ecological sustainability as well as sustainability of energy use from the economics perspective, which the paper addresses as energy in its 3 E form. The paper clearly reveals theoretically ecological limit to energy consumption as evident from the theory of thermodynamic rarity and the theory of cradle to grave describing the situation of 'thanatia'.In this context evaluating various steady state of economic growth which tend to produce a sustainable energy consumption pathway but failure of Hotelling rule along with Hubbert curve provide enough premises for claiming the finiteness of conventional energy sources. Therefore, there exists a need to transform energy system. The paper finally concludes that solar energy is the fundamental source of energy in biosphere. It is the main constituent in the formation of conventional form of energy existing as a natural resource. The main sustainability concern related to extraction of energy, deeply embedded as natural resource emerged when economic system started to extract at a much faster rate compared to the rate at which it was replaced by sun rays. By visualizing the sustainability aspect energy extraction to be dependent on technological efficiency and economic efficiency. The paper strongly supports the need for energy transition towards renewable energy sources but at the same time highlights the concerns related to sustainability of renewable energy sources. Therefore, the paper proposes that the economic system as determined by the mankind needs to alter the consumption pattern to reduce entropy and also discover a more sustainable technology to harness solar energy and make it more economically feasible for end-use.

SDEWES2018.0497

Effect of Staged-Air Box Structure on Combustion and NOx Emissions from a 300 MWe Down-Fired Utility Boiler

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Abstract

Down-fired combustion technology develops quickly for burning low-volatile coals such as anthracite and lean coals, in which both the increased residence time of the fuel particles in the furnace and the up-flowing hot gas favors a high burning rate. However, in practical operation, down-fired boilers still suffer some problems such as unstable combustion, serious slagging, low burnout rate (8-15% unburned carbon in fly ash) and high NO_x emissions (1100-2000 mg/m^3 at 6% O_2).

This paper investigates the effect of the staged-air box structure on the staged-air feeding angle in a 300 MW_e down-fired utility boiler. First, cold airflow experiments on a 1:1-scaled air box model are performed under three different staged-air box structures: the large air box structure, the large air box structure with air deflectors, and the small air box structure. The experimental results show that the air box structure significantly affects the staged-air feeding angle in the staged-air slot outlet zone. The large air box structure has the minimum staged-air inclined angle; the staged-air inclined angle increases by approximately 50% after installing air deflectors in the large air box; and the small air box eliminates the decay of the staged-air angle to achieve the designed value. Then, full-scale simulations of the 300 MW_e utility boiler are carried out under the three different staged-air box structures. The simulation results indicate that the use of the small air box structure can significantly improve the performance of the boiler, e.g., combustion stability enhancement, NOx reduction by 20.7%, and thermal efficiency improvement by an absolute value of 1.72% at full load, which is consistent with the findings from the full-scale measurements on the utility boiler.

SDEWES2018.0501

Overcoming Barriers in Waste Heat Utilization in the Czech Republic: Case Study of Local District Heating

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Abstract

The waste heat utilization represents one of the feasible ways for a significant energy efficiency increase. In most of the European countries the barriers to waste heat utilization are too high, which means the potential remains to a broad extend unutilized. One of the most common barriers is lack of situations in which the waste heat suppliers and users can match their needs.

The contribution addresses the main barriers and their possible solutions identified within the tree years' work on the international CE-HEAT project that focuses on waste heat utilization. The contribution demonstrates some of the issues on the example of the Czech Republic, where the theoretical potential was estimated at 65 PJ a year. When the low potential waste heat is included, this number increases to 110 PJ a year (approx. 7 – 10 % of the total Czech energy consumption). Based on our estimate, at least 40 PJ can be utilized with currently available technologies. This heat can provide households with heating and hot water supply (thanks to a well-prepared technical infrastructure; 1.5 million households use central heating system).

The existing barriers are mostly legal and institutional rather than technical. The supporting programs are hindered by excessive regulation and bureaucracy. Also, the third-party access to the existing grids is rather complicated and is possible under unclear conditions, which prevents a large amount of waste heat from being utilized. The waste heat remains unnoticed by policy makers, which, according to our findings, complicates the use of waste heat in almost all possible ways of using it.

The contribution addresses the main possible ways of overcoming the barriers to waste heat utilization, which are to some extent similar in all European countries that participate in the international CE-HEAT project.

SDEWES2018.0560

Effect of Working Fluids on Binary Plant with ORC - Case Study Geothermal Power Plant „Lunjkovec-Kutnjak"

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Abstract

Over the past 30-35 years, worldwide electricity production based on geothermal sources has increased significantly: the installed generating capacity has grown from 1300 MW in 1975 to almost 18,500 MW in 2017. In 1998 the Energy Institute "Hrvoje Požar" prepared a Program of Geothermal Energy Usage in the Republic of Croatia, which shows that in the Republic of Croatia there are some medium temperature geothermal sources (geothermal water) in the range from 90 to 170 °C, by means of which it is possible to produce electricity in binary plants, either with the Organic Rankine Cycle (ORC) or with the Kalina cycle. However concrete initiatives for the construction of geothermal power plants have only recently been started. In accordance with this authors in previous papers have presented result of an energy-exergy analysis of geothermal resources Velika Ciglena (170 °C), Lunjkovec-Kutnjak (140 °C), Babina Greda (125 °C) and Rečica (120 °C), in order to determine which cycle is better for the conditions in Croatia. On the basis of analysis results that the ORC is thermodynamically better from the Kalina cycle for temperatures of all cited geothermal sources and cooling air, and considering the problems that all the new technologies encounter in their early phase of application, authors propose the application of binary plants using ORC cycle for all medium temperature geothermal sources in the Republic of Croatia. Researches related to the application of the ORC generally deals with the selection of the working fluid, optimization of the ORC unit and the whole plant and analysis of possible modifications with aim to increase its thermodynamic efficiency or net mechanical power output. Although in the available literature, there are a large number of published research results on the selection of the working fluid, however, every geothermal source is a case for itself with respect to the temperature of geothermal water and the cooling fluid on location (water or air). Therefore, in this paper will be presented the results of analysis of the working fluids effect on thermodynamic and techno–economic characteristics of binary plant with ORC - case study of Geothermal Power Plant Lunjkovec-Kutnjak with temperature of geothermal water 140 °C. As the working fluid the next refrigerants and hydrocarbons will be analyzed: isopentane (C_5H_{12}), isobutene (C_4H_{10}), isohexane (C_6H_{14}), R114 ($C_2Cl_2F_4$), R141B ($C_2H_3Cl_2F$) and R142B ($C_2H_3Cl_2F_2$).

SDEWES2018.0596

Cost of Reducing Greenhouse Gas Emissions from Residual Municipal Waste Treatment

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Abstract

Municipal solid waste (MSW) treatment leads to the production of the considerable amount of residual municipal waste (RES), which can be hardly materially recovered. Its treatment represents a worldwide challenge, since the traditional method, landfilling, is greenhouse gas (GHG) emission-intensive. Approx. 128 mil. tons of MSW was landfilled or incinerated within the EU-28 in 2016 and the waste management sector produced 3% of the overall GHG emissions.

The contribution analyses the relation between GHG emissions and cost of RES treatment. A reverse logistic model has been developed to optimise future strategies of RES treatment by waste-to-energy (WtE) facilities in a large geographical area consisting up to hundreds of micro-regions. The problem is a multi-objective mixed integer model, which newly integrates non-linear functions, where costs for RES treatment and avoided GHG emissions are subject to WtE plant capacities. This is due to local aspects of future WtE integration into existing district heating systems and related heat delivery, which is currently produced from fossil fuels. The effect of substitution is locally dependent, which together with the heat demand profile during the year causes non-linear cost and avoided emissions functions.

The results are presented through a case-study for the Czech Republic, where 206 nodes with waste production, 146 landfill sites, 4 existing WtE plants and 32 candidate locations for new WtE plants have been considered. The proposed future concepts involving various processing chains (small WtE, large WtE with complex logistic, mechanical biological treatment prior to incineration), are compared with the current state (2016), where 73% of RES is landfilled.

SDEWES2018.0600

A Comparative Study of Congo Red Dye Biosorption Using Pleurotus Mutilus and Wood Chips

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Abstract

In the present study, the biosorption efficiency and capacity of Pleurotus mutilus (Pm) and Wood chips (Wc) were investigated for the removal of Congo Red dye in aqueous solutions. Effect of various parameters such as pH solution, contact time, initial dye concentration and temperature were examined and optimal experimental conditions were determined. The maximum biosorption capacities of 27 and 10.30 mg dye per gram of (Pm) and (Wc), respectively.

The biosorption experimental data were analyzed by using Langmuir and Freundlich isotherm models. The biosorption behavior of (Pm) and (Wc) towards Congo Red dye removal was best described by the Langmuir isotherm model than Freundlich model based on the values of the coefficient of determination R^2.

The rate of the biosorption process was inspected using the kinetic models of pseudo-first-order, pseudo-second-order. Biosorption kinetic analysis indicated that pseudo-first-order kinetic model fitted very well for the biosorption of Congo Red onto (Pm) and (Wc).

The temperature dependent data of thermodynamic study showed that the biosorption process of both biosorbent (Pm) and (Wc) was spontaneous and endothermic. The study revealed that Pleurotus mutilus has a great potential in removing Congo Red dye compared to Wood chips.

SDEWES2018.0624

A Sustainable Management Strategy for Pig Manure Using Aquatic Plants

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Abstract

Pig meat production is a very important economic activity, which has a high environmental impact due to greenhouse gases emissions and the pollution associated with the produced manure. As a way to minimize those impacts, it is important to develop management models based on new technologies both efficient and with a low cost. Over the last few decades Lemna minor has been used in constructed wetlands, replicating natural ecosystems, to treat wastewaters. The benefits of this treatment system comprise low energy input, high rate of nutrient uptake by aquatic plants and high biomass yield.

The objective of this study is to evaluate the role of different operational and environmental parameters for a sustainable methane generation on a pig farm unit.

In a first step, we have studied the kinetics of Lemna minor growth on a pH 5.8, 16h of photoperiod, photon flux density of 50 µmol/m²s and temperature range between 18ºC-30ºC. The Lemna minor population was observed along 12 days (264h) by counting the number of frondsand quality evaluation criteria, in order to monitor their adaptation. At the end of the assay (21 days), Lemna minor biomass was collected and weighted, as fresh weight. The total protein and total carbohydrates contents were analysed. In a second step a new assay, keeping the same operational conditions, was performed on ideal medium enriched with ammonium sulphate (32mM) to simulate the Lemna minor growth on pig liquid fraction, after bioconversion by anaerobic digestion.

Preliminary results suggested that temperature has a significant effect on Lemna minor growth. Assays carried out at 18ºC were the ones with the highest C/N ratio. Also, the studied revealed that Lemna minor can grow in the enriched ammonium medium, in spite of the negatively affect on the growth rate. These evidences were more understandable in the assays performed at 30ºC. The expected results can serve as a support for the preparation of an analysis of the environmental sustainability of pig production chain.

SDEWES2018.0637

Leasing Large Wind Turbines: Toward a Sustainable Business Model

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Abstract

The financing and economic assessment of large wind turbine (WT) projects were often analyzed in the literature and being optimized to generate benefits. However, these models are mainly based on traditional purchasing schemes of WT. an option often ignored in the wind industry is the use of a leasing scheme to improve not only the economics of WT projects, but also enhance the sustainability of wind turbines while proposed a new product-service system (PSS) model. This paper introduce this scheme and how it can be applied for large wind turbine projects. Two lessors' scenarios were discussed according to the types of leasing contracts proposed. The economic model of leasing applied to WT was also compared to traditional one by using the levelized cost of energy (LCOE) indicator. The results showed the effectiveness of this PSS model and its viability for wind turbines. In addition, we present a qualitative results about how this new model can improve the sustainability of wind turbines. We also discussed the viability of this model and how it can abide to current wind industry regulations. It is thus an asset to improve the performance of wind turbines and their share in national energy mixes. Finally, we conclude the paper by presenting directives and perspectives that need to be investigated to democratize the use of this model in the wind industry.

Poster session 2

SDEWES2018.0036

From Biomass Waste to Tri-Generation: a Life-Cycle Experience in the "Agro-Combined" of Thibar

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Abstract

The production of energy from biomass, including waste, is a key strategy to ensure the transition toward an eco-innovative and low-carbon economy. In order to create a sustainable energy supply chain from biomass it is important to manage the potential environmental issues related to its use, especially in those countries where it is one of the main sources of energy.

In this context, this paper presents a life-cycle environmental analysis of energy produced by biogas obtained by biomass waste and fuelled in a tri-generation pilot plant located in Thibar (Tunisia).

The analysis was developed by applying the Life Cycle Assessment methodology, according to the international standards of the ISO 14040 series. Being the function of the examined system the tri-generation of different forms of energy, in order to take into account their different quality, the functional unit was 1 MJ of exergy produced. The analysis followed a "from cradle to grave" approach and included the construction and end-of-life of the plant, the supply of waste biomass due to agriculture and livestock, its use for biogas production in a bio-digestion plant and the biogas combustion for the production of electricity, thermal energy for heat and refrigeration energy for chilled water production.

The results of the analysis showed that the construction of the examined plant is responsible of about 76% of the primary energy consumption and gives a contribution higher than 90% on the resource depletion and ionising radiation, and of about 50% on the ozone depletion. The operation causes about 66% of the impact on human toxicity - cancer effects and more than 90% of the other environmental impacts, except for the ecotoxicity of freshwater mainly caused during the end-of life step.

The development of the analysis also allowed the identification of the main critical environmental issues of each step of the examined supply chain, to be considered for an improvement of the eco-profile of the functional unit.

The study is one of the first applications of environmental analysis to tri-generation from biomass waste in developing countries, and can be considered a guideline for other similar countries for transforming the threat of waste in an opportunity. Furthermore, it gives some suggestions for a cleaner management of biomass waste for energy production, in order to achieve a bio-economy based on energy from renewable sources.

SDEWES2018.0039

Dynamic Simulation of a Solar Based Ground Source Heat Pump Including an Electric Energy Storage for an Office Application

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Abstract

Solar based energy conversion systems are becoming a promising alternative to fossil fuel based technologies. In this paper the attention is focused on a photovoltaic (PV) system satisfying energy demand of an office building. Renewable electric energy available from PV panels is partly used to activate a ground source heat pump to meet space heating and cooling demand and partly used for other electric loads (lights, printers, computers, etc.). Energy and environmental analysis of the proposed system considering different PV field capacity (4.5 kW, 6.0 kW, 7.5 kW) and electric battery size (3.2 kWh, 6.4 kWh, 9.6 kWh) is performed with dynamic simulation software TRNSYS. A saving in terms of primary energy and a reduction of equivalent CO_2 emission up to 97% can be obtained by renewable based with respect to a conventional system consisting of a natural gas fuelled boiler for space heating, an electric chiller for space cooling and the national electric grid for electric demand.

SDEWES2018.0068

Exergy Analysis of a Novel Air Pre-Purification Unit for Cryogenic Fractionation Based on Low-Pressure Supersonic Separator Combined with Finishing Adsorption Step

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Abstract

Cryogenic air fractionation requires raw air compression and pre-purification, and the conventional process – FULL-TSA – uses Temperature-Swing-Adsorption (TSA) with large activated-alumina beds for removing H_2O and small molecular-sieve beds for CO_2 and trace-species. A novel alternative – SS-TSA – prescribes a Supersonic Separator (SS) abating 98.65% H_2O followed by molecular-sieve TSA for finishing purification. A new variant deriving from SS-TSA – SS-TSA-HI – uses compression heat to regenerate TSA beds. Exergy analysis of FULL-TSA, SS-TSA and SS-TSA-HI was executed to investigate thermodynamic performances also locating where improvements can better reduce utilities consumption. Air compression and cooling steps were unveiled as major exergy destructors, with SS-TSA-HI being slightly superior at this point due to lower temperature approach in intercoolers. Utilization of SS reduced exergy loss of pre-purification by 61% for savings on steam and nitrogen demand in TSA system. Overall exergy efficiencies of FULL-TSA, SS-TSA and SS-TSA-HI were found as 57.9%, 60.0%, and 60.3%, respectively.

SDEWES2018.0161

Connectivity Between Various Types of Energy Measurement Systems into Single Platform for Data Visualization and Energy Management

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Abstract

A comparative analysis between three different energy monitoring platforms used in Slovenia was made and evaluated. All three platforms enable measurement of energy use measured with various types of instruments and enable production of custom visualization of measured parameters that suits customers' needs. Comparison between used smart meters, energy monitors, storage solutions, possibilities of data visualization and real time energy monitoring were made.

A potential for development additional end-user dashboards within each platform and connectivity to various mobile platforms was assessed and evaluated to determine integration with third-party analytics frameworks and solutions. The overall improvement of energy efficiency and energy saving in buildings was assessed and approaches to changing behavior of building users and promoting energy efficiency measures were compared.

Other energy management platform solutions were examined to determine most versatile, interconnected holistic solutions for further development and larger interconnected integration of smart buildings into smart city and emerging energy and data economy.

SDEWES2018.0177

Evaluation of an Integrated Energy System in the Park of Madonie

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Abstract

This paper analyses technical and economic aspects relative to a hypothetical wind farm installed inside the park of Madonie (Sicily) that produces electric energy for the direct use and to supply an electrolytic system for the production of hydrogen. User is formed by approximately 20,000 persons who live in the mountain localities of the park. Global energy required by user was estimated carrying out hypotheses on daily power demand. Discontinuous power makes inescapable to connect wind farm to grid, so that energy demand of user is partially satisfied by means of energy wind, while the remaining part becomes from grid. Surplus of power that turbines make available when wind speed is particularly high is used to supply electrolytic system.

The context is the Sicilian island, the biggest Italian region, located in the middle Mediterranean Sea, having a population about five million. Around Sicily, there are several smaller islands, most of them living on tourism and local agriculture with very valued typical products.

Sicily is a region in the southern part of Italy with a high potential of renewable energy sources and it is an attractive market for investments in the sector.

According to studies of Ricerca Sistema Energetico-RSE (GSE) in the medium term the potential generation from hydropower for Sicily is over 30 ktoe, from solar sources is close to 231 ktoe, from wind power it is 360 ktoe, for biomass 292 ktoe, from biogas and bio-liquids 63.5 ktoe and from geothermal 185.1 ktoe. In the last years the Sicilian energy system has shown a growing trend of the RES plants, especially for the power production.

The wind resource availability is much less predictable than solar, as conditioned by many factors, many of which of local nature (terrain features, presence of obstacles, mountains, hills, buildings, trees etc.).

In Sicily a large part of the island appears to have resource availability between 1,500 and 2,000 MWh/MW installed, while a few areas exceed 3,500 MWh/MW (Mount Etna).

Tendentially, the areas near the coastline are characterized by higher values of wind speed respect the inland area, flowing also with a greater regularity. The Western area of Sicily is characterized by greater values of wind energy potential. Its annual specific energy potential varies from a maximum along the coastal area of 3,000 MWh/MW to a minimum of 2,000 MWh/MW installed.

SDEWES2018.0182

Investigating Energy Saving Potential in a Big Shopping Centre Through Ventilation Control

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Abstract

The paper investigates the potential energy savings in the context of big shopping centres, thanks to the introduction of innovative technologies able to control the ventilation according the real requirement for comfort and health of indoor space. The paper analyses a big shopping centre as case of study, where the ventilation is realized with a central air-conditioning plant, working with fixed air flows. The first step considers the installation of heat recovery exchange, the second the introduction of a control system able to module the air exchange, according the real requirements. An energetic and economic evaluation is reported.

In the present paper, the energy and economic saving deriving from the introduction of automation in ventilation system will be evaluated considering as a case study a shopping centre with a gross floor area equal to 7,700 m^2. This building is located in Palermo, Sicily, and currently has an annual expense equal to 403,940 €/year, corresponding to 2.58 GWh/y.

The electrical consumption for HVAC in 2016 is equal to 1.17 GWh/y, corresponding to 182,755 €. In order to consider the potential savings, the AS-IS scenario will be improved considering three different cases:

- installation of a sensible heat recovery exchanger on the extraction duct;
- installation of inverter-equipped air fan, regulated by internal pollutant concentration;
- installation of sensible heat recovery exchanger on the extraction duct and inverter-equipped air fan, regulated by internal pollutant concentration.

These three improvement cases will be compared according to these criteria:

- primary energy saving related to fans electricity consumption;
- primary energy saving related to airflow thermal treatments, evaluated by a heating and cooling degree-days based approach;
- net present value of the investment;
- payback time of the investment.

SDEWES2018.0185

Copper Biosortion in Fixed Bed Reactors. Comparison Between Sortion Cycles

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Abstract

The contamination by heavy metals in water bodies is very dangerous for the environment due to the high toxicity they present and the tendency to bioaccumulate in living organisms. Extracting the pollutant from the aqueous effluents then becomes not only a legal requirement, but also urgent for the health of the population. Biosorption in beds filled with low-cost materials, such as marine algae, plants, bacteria, fungi or agro-industrial waste, is an effective technology for the retention of metals from aqueous effluents. For a biosorbent to have an industrial utility, a jump in scale must be made from the study in batch experiments to know the parameters that govern the biosorption in fixed-bed reactors with continuous flow. This arrangement has the additional advantage in the use of a reduced space for a treatment of large volumes of effluents, an optimal control in the variation of the parameters for the optimization of the process and the future possibility of projection on an industrial scale. This study allows to estimate the useful life of a reactor, its sizing to treat a certain amount of effluent with a certain concentration and the estimation of the costs to implement the proposed methodology. One way to test the performance of a TUB is to perform fluid dynamics tests, obtaining the rupture curves and determining the axial dispersion module. In addition, when comparing the curves obtained with the adsorbent and with an inert filler such as glass spheres, the effective sorption can be found. In this work it was determined that the reactor behaves like a piston flow and the decrease in retention between two Cu (II) sorption cycles was studied, using biomass of aquatic macrophytes of the Azolla species as a filler. Based on the first sorption, the sorbent capacity of Azolla decreased by 55%. For the desorption between cycles, HCl was used.

SDEWES2018.0212

Ahp Based Emergency Power Management System for Building Resilience

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Abstract

This study proposed and validate a AHP based power management system to maintain important functions of buildings when the building must operate with only a limited power which emergency power and storage facility and power source can provide in an emergency situation where power supply is not stable.

Important functions of the building can be interpreted differently depending on the purpose and characteristics of the building and the circumstance of the subject using them and a large number of commercial buildings have changes in the room or function during operational stage rather than the building planning stage. Therefore,there is a problem that pre-installed emergency energy supply system cannot consider the characteristics of the changing building. Therefore, the power management system considering the important building functions in the place is required in an emergency situation where power supply is not stable.

the purpose of the system is to provide a power management method and system which help keep core functions of the building by deriving the room configuration which provides an electric power and performing the power supply management according to the derived configuration while considering the importance of the room existing in the building and the timespecific power amount to be used, when a building has to operate with a limited power that emergency power generation/ storage facilities and power source can provide in an emergency situation where power supply is not stable. Especially, this is a system with a feature that the importance of the room by the purpose of the building and residents can be frequently considered and in an emergency, it can be applied in the existing building where power supply plan is not established.

In this paper, we propose a power management system based on AHP from the building manager and facility expert, and implemented prototype test hard ware and software system. And we simulated feasibility based on the usage data of existing buildings.

SDEWES2018.0248

An Open Question for the European Bioenergy Future: How Should be Food Waste Energy Management?

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Abstract

Food waste (FW) represents a significant loss of resources invested in their production, leading to the development of numerous reduction strategies. At the same time, a larger share of renewable energy for greenhouse gas emissions (GHG) mitigation are stated by the new European energy strategy. Waste reduction strategies aimed at simply halving the generation of FW might hinder energy policies seeking to expand bioenergy production as means for GHG emissions mitigation. This work aims at quantifying the potential reduction of FW in the Spanish agri-food system and assessing its implications for bioenergy generation and GHG emissions mitigation. Results suggest that consumption and agricultural production contribute to half of FW generation. Its reduction as a result of current waste strategies, and potential redirection to other processes, could increase pressure on the of other biomass resources generation, potentially leading to increased GHG emissions and exacerbating the food – energy competition for land.

This work aims at (1) quantifying the potential reduction of food waste in the Spanish agri-food system under different waste reduction strategies, and (2) assessing its implications for bioenergy generation in Spain. In order to analyse the climatic merits, i.e. reduction in GHG emissions, of alternative scenarios of food waste generation and utilization, we develop a new consequential life cycle assessment (cLCA) method, which links LCA to the European Energy System model developed at UCL, ETM-UCL. By enabling this connection, we are able to analyse the climatic merits of different scenarios in the short term (to 2030) and mid-term (2050), i.e. considering the transformation of the Spanish energy system as a whole, how much bioenergy would be needed for a low carbon economy, and finally what bioenergy would substitute at different points in time. While unravelling trade-offs between the amount and type of food waste potentially available for bioenergy generation and the GHG profile of Spanish energy generation, our results highlight the need of addressing the food waste problem holistically, instead of setting targets at the level of reduction in the flow of food waste mass generation.

SDEWES2018.0270

Simulation Models of an Electric-Driven Smart Window: Energy and Visual Performances

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Abstract

A significant portion of the total worldwide energy demand can be attributed to energy demand of building sector. In this context, the electric-driven smart window technology, especially for the buildings with a large glazed surface, can help to significantly reduce the energy consumption as well as to improve the thermal and visual indoor comfort. Indeed, the correct use of daylight allows to reduce the cooling load as well as the electric energy for lighting.

With the aim to evaluate the thermal and visual behavior of electric-driven window,“in situ” measurements were performed. The experimental data were acquired using a full-scale facility.

In this paper, the “in situ” measurements were used to develop, calibrate and validate thermal and visual simulation models of an electric-driven device, into the simulation software TRNSYS.

The validated simulation models were used to predict the ability of electric-driven windows, integrated into a typical reference building, to control the indoor environment, upon varying boundary conditions.

With this aim, preliminary energy and visual analyses were carried out considering different control logics. Finally, the simulation results of the electric-driven window were compared with those performed by means a convention double glazing window

SDEWES2018.0274

Biomass District Heating in Italy: Results of a Wide Survey of Operational Conditions

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Abstract

District heating has a marginal role in satisfying space heating in buildings in Italy, but, if we take into account the plants fuelled by renewable sources or waste heat, we can observe a constant increase of the users' connection.

The research aims to deeply investigate a large sample of biomass district heating plants (BDHP) operating in Italy. These plants represent an occasion to encourage the creation of a local energy supply chains that use forest by-products as an alternative to traditional fossil fuels, bringing important benefits also on the economic and territorial local conditions.

By a systematic campaign involving plants in operation, a database was developed and compiled in order to evaluate the technical features and the energy, environmental and economic performance of BDHP, mainly located in the northern Italy and fuelled almost by wooden biomass. The evaluation were performed implementing an Excel sheet able to collect and organize data acquired as input, to evaluate a set of performance indexes (30 in total, defined and documented) and to graphically represent the achieved results.

This analysis represents a contribution to respond to pressing and controversial issues related to the thermal use of biomass such as: characterization of the source, definition of the substitute scenarios, contribute to thermal renewables, carbon neutrality, atmospheric emissions of pollutants, benefits on the management of local forests and territorial protection, creation of local enterprises.

To that end also a sensitivity analysis has been accomplished.

Main strength of the research is to be based on reliable and representative set of operational data: a sample of 65 plants of different size and features, in a small part operating to provide heat and power.

Results demonstrate a non-uniform and quite surprising panorama, because of the local peculiar conditions of installation and operation of the analysed systems.

Generally speaking, the reduction of heat lost between heat generation and final users seems to be the most important lever to improve the efficiency of these systems.

After a deep analysis of the results, guide lines about the possible evolution of this kind of plants and for the feasibility of new ones were mentioned, giving also an analytic evaluation of the future potentiality in each Italian region with suitable climatic conditions.

The work represents a basis to identify the future challenges of BDHP in the framework of the path towards sustainable energy systems, with particular regards to smart district heating, cascade use of heat and possibility of cogeneration and district cooling.

SDEWES2018.0285

Analysis of Convective Heat Exchange Processes of Refrigerating Fluids

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Abstract

Fluorinated Greenhouse gases (F-gases) are very potent greenhouse gases which contribute to climate change if released to atmosphere. The F-gas Regulation (EU) n. 517/2014, which came into force on 1 January 2015, aims to drastically reduce greenhouse gas emissions, limiting them to 79% by 2030. On October 15, 2016 a landmark binding agreement was signed by 197 nations in Kigali as an amendment to the Montreal Protocol, giving a clear signal that Hydrofluorocarbons (HFCs) will be phased down on a global scale at an accelerated rate than agreed upon before. The introduction of these limitations, suggests in the field of refrigeration, the use of natural refrigerants such as ammonia and carbon dioxide. Design of heat exchangers of refrigeration plants involves the use of reliable correlations for the estimation of the heat exchange coefficients of evaporators and of condensers where the refrigerant fluid undergoes the phase change from liquid to steam. The correlations proposed in the literature are largely of an exclusively empirical nature.

In this paper is proposed the use of a correlation methodology of heat exchange data based on the thermofluidodynamics of the polyphase flows using the Wallis hydrodynamic model of "drift flows" suitably adapted to the different cases. The use of the hydrodynamic model with entrainment, permits the evaluation of the contributions of the main phenomena involved in the process along the diabatic outflow. The correlation methodology was calibrated using literature data related to measures concerning evaporation in horizontal ducts of ammonia. Appropriate correlations have been derived allowing the estimation of heat transmission coefficient and the analysis of the evaporation process of ammonia in horizontal tubes. The illustred methodology therefore permits the deployment of reliable correlations that can be used in the project of evaporators. The high correlation coefficients proving the validity of the methodology, also demonstrate its reliability. A comparison between the estimated values of convective heat transfer with experimentally determined values shows that the differences are less than 20%.

SDEWES2018.0302

Sea Wave Energy to Supply the Aeolian Islands in Sustainable Way

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Abstract

The diffusion of technologies supplied by Renewable Energy Sources (RES) is contributing in the challenge of reduction of energy dependence from fossil fuels, avoiding the emission of several polluting substances and greenhouse gases (GHG).

Despite the technological development and important results around the world, in several remote areas or small islands the electrical energy production is based on obsolete technologies, supplied by fossil fuels. This solution is not sustainable for the environment, as the emissions of several pollutants.

Focusing the attention on small islands, these areas usually have a standalone grid, as the high cost to build an electrical connection to the mainland, in comparison with the electrical demand. For this reason, the electrical energy is typically produced in situ, trusting to diesel engines. The fuel is usually shipped from the mainland, so bad weather condition put at risk the energy supply of these territories.

As example, the paper analyses the Aeolian Islands, located in the Tyrrhenian Sea, at north of Sicily. The archipelago includes several islands, which the main are: Lipari, Salina, Vulcano, Stromboli, Filicudi, Alicudi, Panarea and Basiluzzo. The electrical production is entirely based on diesel generators.

As other small islands along the Mediterranean Sea, the Aeolian Islands show a chronical water scarcity, so freshwater is usually transported by tankers, especially in summer as the increasing of population for tourism. Only Lipari and Vulcano are equipped with desalination and wastewater treatments plants.

The renewable energy sources are very underused, in particular the only exploited source is solar, with very limited applications, instead its high potential.

So, in this context the paper analyses the current energy demand and evaluate the availability of renewable energy sources in the Aeolian Islands. With the goal of satisfying the electrical energy consumption in a sustainable way, the paper proposes an energetic mix based on renewable energy sources. The mix includes also sea wave, a new entry in the renewable energy context. A device for the utilization of this resource is presented.

SDEWES2018.0309

Integration of PVT Systems into a Solar District Heating Network Serving a Small-Scale Italian Urban Area

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Abstract

EU directives aim at promoting a wide diffusion and efficient exploitation of renewable energies. Solar energy, as a pollution-free, inexhaustible and affordable renewable resource, is one of the most attractive options to achieve the EU targets. One of the barriers to solar energy technology lies in the mismatch between thermal energy supply during the summer and heating demand during the winter: long-term thermal energy storages could represent a key technology to address and close this gap.

In this paper a district heating system including a solar field to recover the solar energy, a short-term thermal energy storage, a long-term double U-pipe vertical borehole thermal energy storage, a natural gas-fired back-up boiler and a heat distribution network is investigated. The plant is devoted to satisfy the energy demand for heating purposes and domestic hot water production of a small-scale urban district composed of 6 typical single-family houses and 3 typical schools under the climatic conditions of Naples (south of Italy). The investigation has been performed by considering four solar field configurations consisting of different combinations of solar thermal collectors and photovoltaic/thermal panels covering the same floor area.

The analysis has been performed with reference to a 5-year period by means of the dynamic simulation software TRNSYS. The simulation results have been compared with those associated to a conventional heating system in terms of primary energy consumption, carbon dioxide equivalent emissions, operating costs and simple pay-back period in order to assess the energy, environmental and economic feasibility of the proposed plant.

SDEWES2018.0310

Methods for Estimating Buildings Energy Demand at District Level as Input for Defining Distributed Energy Scenarios

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Abstract

In the framework of distributed energy planning and related optimization strategies, evaluating reliable energy demand/consumption profiles of different energy segments has a prominent role. At the same time, it is a quite challenging task, since at community level the availability of real energy profiles is not always widespread, therefore their accurate assessment requires high computational time. In fact, even available, yearly local energy balances expressed in terms of primary energy or final energy are not suitable and the same is for energy audits, generally available for non-representative sample of buildings.

The scientific literature is rich of contributions reporting different approaches for estimating urban energy demands.

In this framework, by a first desk research, a selection and analysis of the methods adopted and their evaluation according to the applications and the quality of the results achieved has been accomplished. This critical review starts from the selection and analysis of about fifty scientific contributions. These contributions include the definition of energy demands with the aim of defining scenarios for improvement of the local energy systems. We observed that half of the mentioned studies face this issue in deep, but they underline lacks in the definition of the hourly profile of the energy demands. In order to explore this critical point, studies dedicated to the methods of assessing the hourly demand for various end-uses were further investigated. Therefore, by a second desk research, more than thirty scientific contributions were selected and analysed.

The research demonstrates that a wide range of methods and experiences are available and that there are also applicative cases, but the potential replicability of the methods is controversy.

From the methodological point of view, a set of criteria for classifying the selected contributions was defined and useful tables were elaborated with the aim of support the choice of the available methods.

The tables report details about the context of application of the methods (i.e. location, spatial scale, investigated sector and energy service) and the adopted approach (i.e. used software, calculation method and/or data source, time resolution and/or horizon of the determined energy demand).

The stakeholders involved in urban energy planning and in the definition of improved energy scenarios, even if without particular expertise and consciousness, could effectively benefit from this review.

SDEWES2018.0317

Long-Term Economic Impacts of Energy Development Scenarios: Insights from Lithuanian Case

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Abstract

The debates on energy strategies, especially in case of new investments, often include broad economic effects such as employment, value-added, taxes or the state of current account. Evaluation of such impacts provides important information about the possible consequences of strategic decisions in the energy sector. This information might be crucial for the decision makers, since it reflects the influence on the entire society rather than narrow effects within the energy sector.

The current situation in neighbouring electricity markets and the availability of strong interconnections make electricity import more competitive than the local generation by the most of the existing or prospective electricity generators in Lithuania. However, the need of increased local generation is advocated by energy security issues (especially, possible increase of imported electricity price) and additional economic effects. Allocation of European Structural funds to the energy sector is considered as an attractive option to incentivise large investments and to promote local electricity generation with no obvious harm to the state budget.

The main objective of this paper is to explore employment and other long-term economic impacts of Lithuanian energy development scenarios which cover above mentioned issues. The analysis up to 2050 is performed using recursive-dynamic computable general equilibrium (CGE) model EnEkonLT linked with the bottom-up model of the energy sector.

Higher electricity import prices have a clearnegative influence on economic development: the increase of electricity import prices by 50% may increase unemployment rate by almost 0.7% and reduce the GDP by more than 0.6%. The net negative impact is obtaineddespite increasing local electricity generation, employment and value added in the energy sector. In case of higher import prices, national energy sector enjoys better competitive position that leads to the replacement of imported electricity by increasing local generation. However, local electricity generation requires a substantial amount of imported commodities and electricity import is in fact replaced by technology import. Therefore, uncompetitive local electricity generation fails to be justified by positive economic externalities.

The “lean” energy development scenarios, where the energy sector requires less investment and fewer expenses for the operation, seem to be preferable over protectionistic ones, since electricity price is more important determinant of economic growth and employment creation than the amount of locally generated electricity.

SDEWES2018.0320

1-D Heat Conduction in the Fractal Semi-Cokes

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Abstract

The semi-cokes carry a lot of waste heat and the inner morphology of semi-cokes has great effects on heat conduction characteristics, so the inner morphology and heat conduction characteristics of semi-cokes were investigated. The non-destructive CT was employed to obtain the inner morphology of semi-cokes and the image binarization processing was used to segment the image. With the MATLAB program, the fractal dimension, porosity and average number of contact of semi-cokes were calculated. The DRS-III thermal conductivity tester was used to measure and calculate the temperature distribution, heat flux and equivalent thermal conductivity of semi-cokes. The effects of inner morphology on heat conduction characteristics of semi-cokes were studied. The effective thermal conductivity formula derived from fractal theory, and the formula takes into account the geometric structure, the thermal contact resistance and equivalent diameter of semi-cokes. The results showed that, with increasing the diameter of semi-cokes from 3mm to 37mm, the fractal dimension and average number of contact decrease gradually, but the porosity, the temperature, the heat flux and equivalent thermal conductivity increase gradually. With the decrease of the fractal dimension and the average number of contact, the heat flux and equivalent thermal conductivity increase gradually, and the effect of porosity on the heat flux and equivalent thermal conductivity is less than the fractal dimension and average number of contact. The fractal expression of the equivalent thermal conductivity for semi-cokes was obtained and it can describe the heat conduction of semi-cokes very well.

SDEWES2018.0321

Study on Flow Layer and Trace of Calcined Petroleum Coke in Heat Exchanger

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Abstract

The calcined petroleum coke (CPC) is petroleum coke after high temperature calcinated and, it is an important industrial base material. The CPC carries a lot of residual heat when it moves away from the calciner to enter the heat exchanger. It is of great significance to achieve efficient recycling of energy conservation of waste heat for both energy saving and improving the quality of calcined petroleum coke. The flow characteristics of the CPC particles have a great influence on the heat transfer, therefore, in this paper, using self-built visual table of CPC waste heat recovery heat exchanger, the variation of CPC particle speed and particle trajectory in a heat exchanger, and the influence of particle size and flow speed on the moving trace of convection are studied. The results show that the overall speed of the flow layer is basically the same as the setting speed in the whole flow process; the speed of the flow layer varies greatly when the CPC flows through the upper header of internal heat exchanger, and at the same time it shows the phenomenon of local collapse and particle rolling; the particle size has great influence on the trace, and the setting flow rate has little influence on the trace within the parameters control range.

SDEWES2018.0329

Application of Ray Tracing Analysis in the Design of Complex Flat Plate Collectors

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Abstract

Flat plate solar thermal collectors are a widespread solar thermal technology, but they can experience overheating during periods of high insolation and low demand for hot water. This imposes considerable limitations on materials that can be used in their production. While in some commercially available collectors the overheating problem is mitigated by employing design features which reduce the stagnation temperature of the collector, there is currently no method that has gained wide use or provided an effective solution for the problem. Therefore, there is still a need for a cost effective and preferably passive method of limiting or preventing overheating, which leads to the development of increasingly complex designs. For solutions which employ complex geometries an analysis of the optical properties and thermal characteristics of the collector is required. While the use of ray tracing computational tools in designing and analyzing concentrating collectors is now commonplace, no evidence of its use in flat plate collector design has been found in the literature. This is despite the fact that some new flat plate collectors are now already of such complex design which requires ray tracing analysis to enable reliable modeling of the thermal performances in a CFD software. To address this issue, this paper analyzes the viability of using ray tracing analysis for complex designs of different types of flat plate collector and develops a simulation model which is compared with the measurements on a model collector. The results of these simulations are then used as input values for CFD modeling of the collector thermal characteristics. The overall simulation results proved that ray tracing analysis yields reliable input values for computing thermal performances of flat plate solar collectors of both simple and complex designs.

SDEWES2018.0343

Energy Analysis of a Regional District Using 3D Urban Modeling

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Abstract

The paper analyses the energetic performance of wastewater treatment plants (WWTP) in the US, Austria and Germany. Indicators and metrics have been defined to compare key performance indicators in the different countries with a focus on energy requirements for the water sector. Monitoring data from New York (US) and Ludwigsburg (Germany) were used to validate a dynamic simulation model of an activated sludge tank model. The goal is to assess the feasibility of implementing demand response (DR) strategies and integrating renewable energy sources as an alternative of the electric grid in the operation of wastewater treatment plants. A model was developed to analyze the potential of turning off the oxygen supply to the activated sludge tank and assessing the effects on the blower power and effluent COD concentration. In addition the biogas production was estimated by a simple equation. A shut off of blowers for 3 hours reduced the daily energy consumed by 4.3% on average. When turning off the blowers by 6 hours daily, an energy reduction of 10% on average was obtained. The simulation results show that shutting off the blowers in a WWTP for DR actions can be interesting in the Water-Energy Nexus.

SDEWES2018.0385

An Efficient Waste Heat Recovery System for Solid Particles Producing from Rotary Kiln

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Abstract

The waste heat of solid particles including solid products and residues in industrial production per year of China is approximately equivalent to the heat of 1 million tons of standard coal, which is in a large amount and is worth to be reused. As a typical equipment producing solid particles in wide distribution of size and temperature, the rotary kiln is urgent to be focused on. Herein, efficient waste heat recovery systems that can be applicable to different rotary kiln is established and applied to industrial practice. For rotary kiln with high ground clearance, vertical heat recovery systems are developed. To enhance the heat transfer rate in the gas-side, plug-in components including SiC-honeycomb and metal-honeycomb type, with specific surface area 100~2000 m^2/m^3 are designed. By heat balance calculation, the heat recovery efficiency of vertical type system with SiC-honeycomb embedded can up to 90%. For rotary kiln with low ground clearance, a horizontal heat recovery system with discontinuous screw leaves is designed. The screw leaves can not only result in an efficient heat recovery, but also lead to a uniform discharge of solid particles. Through industrial application of vertical recovery systems, the waste energy gets efficient reuse and can reduce the fuel cost of rotary kiln by 4 ~9 million RMB per year.

SDEWES2018.0386

An Integrated Technology Combing Efficient Purification and Waste Heat Recovery for Flue Gas with High Temperature and High Dust

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Abstract

High temperature flue gas (> 800 C) with a higher energy grade and a greater recycle value is usually generated in metallurgical, petrochemical, building materials, electric power and other process industries. Those energy are difficult to be recycled due to the high dust content (≥2000mg/m3), and occasionally corrosive- and cohesive-materials in the gas. Herein, in order to solve the bottleneck problem of efficient waste heat recovery from flue gas with high temperature and high dust content, a novel integrated technology combing with purification and waste heat recovery processes is proposed in this study. The three-dimensional metal honeycomb with oversized surface and the stainless steel fiber cloth (SSFC) with dense woven are the main important components in the integrated technology. Through the structure and heat transfer characteristics simulation and the actual orthogonal experiment design, the optimized structure and size of the three-dimensional metal honeycomb are obtained. According to the experiments studies, the heat transfer and purification characteristics of the integrated technology are represented. Two structure parameters (different the honeycomb porosity and the mesh numbers of SSFC), and three different conditions (different the flue gas inlet temperatures, the filtration velocity, and the dust inlet concentrations) are designed for measuring the heat recovery and purification performance. The results show that with the honeycomb porosity fixing in 0.4-0.8 and the SSFC mesh number setting in 500-1500, the waste heat recovery rate of the technology can achieve more than 70%, and the purification efficiency can reach to 99.8% or higher at the same time under a lower resistance condition.

SDEWES2018.0413

Optimization of Wave Energy Converter: Deim Point Absorber II

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Abstract

The paper presents a possible solution to optimize a wave energy converter, device able to exploit the wave energy resource. The utilization of this technology shows also positive aspects, thanks to the limited visual and environmental impacts. This system could be also installed in reserved areas, being similar to signal buoys, simplifying the problem of energy supply in small islands. In order to exploit the wave energy potential in the Mediterranean Sea, the department of Energy of Palermo University realized a first prototype of the electrical linear generator, that is the main component of the wave energy converter. This electrical machine can be operated by a two-floating buoys system, able to produce a linear vertical motion. The main goal of this paper is investigating the advantages and the disadvantages of the utilization of steel materials to realize the stator of linear generators. Thus, starting from the prototype already realized, the Authors analyses the effects produced by the replacement of steel in the stator with a

non-magnetic material. As terms of comparison, the Authors considered the analysis of no-load voltages, using a three-phases connection of windings, and magnetic force produced by the interaction of magnets with the stator. Each aspect above mentioned was studied through numerical simulation (FEM tools) and mathematical models.

SDEWES2018.0427

Numerical Analysis of Design Options Aimed at Heating Historical Churches

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Abstract

Historical churches suffer issues when referring to indoor climate and comfort, even more if it hosts even paintings or frescoes. As a consequence, the design of heating systems for historical churches must take into account both human comfort and masterpiece preservation, and accounting with installation feasibility and costs. This paper relates the analysis performed to choose among four heating systems, characterized by different heat delivery units and heat generation devices. Various conditions were considered, related both to church size and to the level of preservation needed. In the frame of this analysis both CFD (Computational Fluid Dynamics) and building energy simulation tools were used and led to the implementation of basic guidelines to be followed by designers when defining heating systems for historical churches.

SDEWES2018.0430

The Effect of Taxes on the Utilisation of Excess Heat in the Danish District Heating Systems

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Abstract

Denmark is heading towards a fossil-neutral energy system in 2050. Over 60% of the future heating demand is expected to be supplied by district heating (DH). Traditional DH, based on fossil fuel fired combined heat and power plants cannot be a suitable solution. The future renewable energy system should, however, maintain low costs and have a low environmental impact.

Previous works identified that, from a socio-economic perspective, excess heat (EH) from thermal processes in the manufacturing industry could supply 5% of the future DH demand in Denmark. In some regions up to 8% would be possible, but on the national scale currently only 2% of the DH is supplied from EH. Therefore, we have analysed the cost-optimal use of industrial EH in DH supply from private-economic and socio-economic perspective.

The analyses are performed by the TIMES-DK model until 2050 for an unconstrained system and for fossil fuel free systems from 2050 and 2040, respectively. TIMES-DK is the only full-foresight optimisation model covering all sectors of the Danish energy system. We have used a general discount rate of 4% in the socio-economic perspective and a span between 4% and 10% in the private-economic perspective to represent that private investors are looking for a higher return on investments.

The results show that the cost of EH (including the profit for the industrial facility) have the highest influence on the profitability of EH. The tax on EH is the second most important economic factor. Its avoidance would increase the use of low temperature heat within DH areas and increase the feasibility of connecting industries outside the DH. The desire of industrial facilities to have a high rate of return greatly influences the investment heavy technologies such as transmission pipelines. As a result, the remote industries become less feasible in the private-economic scenarios.

SDEWES2018.0482

Assessment of the Mean Radiant Temperature in Urban Areas: Comparison of Alternative Methods

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Abstract

Mean radiant temperature may play a pivotal role in the assessment of the outdoor environmental conditions in urban areas. However, its assessment in urban settings is not a simple task owing to the presence of complex and articulated environment and of solar radiation. The article aims to perform a comparison among the results yielded by different methods: the globe-thermometer method, and the six-directional technique. The scope of such a survey is an analysis of the actual appropriateness of the more practical, albeit less accurate, globe-thermometer method to outdoor environments. Furthermore, an analytical model, previously elaborated by the authors and here modified to make it applicable to outdoor environment, was also considered with a view to verifying its accuracy in predicting the effect of solar radiation. To fulfil all the tasks an experimental investigation was carried out, involving a globe-thermometer with a diameter of 150 mm, usually used in indoor environments.

SDEWES2018.0506

The Electricity Market Structure in Greece and the Paradox of Renewable Energy Sources

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Abstract

The European Union, in an effort to boost the use of Renewable Energy Sources (RES) in power generation, applies supportive tools consisting in financial motivation either as grants or as subsidies. According to welfare economics a subsidy should reflect the external benefits; otherwise a distortion of competition takes place. The most widespread method to calculate externalities is the avoided cost approach, despite the fact that it encounters equally all the RES units leading to technological neutrality.

In the present article the avoided cost approach, with the objective of social justification of RES subsidies/ feed in tariffs (FITs) in the case of Greece is applied. The results show a high gap between the current FITs and the suggested ones amounting to approximately 40%. This uncomfortable outcome indicates that, at least in the case of Greece, either the level of the current guaranteed tariffs is not socially justified, or the CO_2 value derived from the European carbon market does not reflect the real social cost, or that the avoided cost method, alone, is not adequate to explain the level of subsidies. In the light of the foregoing, the need for the development of a concrete and integrated methodology for calculating all RES externalities is emerged.

SDEWES2018.0527

Multi-Objective Particle Swarm Optimal Sizing of a Renewable Hybrid Power Plant with Storage

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Abstract

The installation of new power plants based on Renewable Energy Sources (RES), located on different sites and connected to the electrical grid, can improve the grid stability and help achieve the power transition challenge. As the renewable resources are often intermittent, these plants need to store energy to continuously supply the consumers and fulfill the energy regulation commission constraints.

The sizing of a plant that includes one or more RES and a storage is a complex problem. The cost of each component (sources, storages and power electronics) have to be kept as low as possible while the power produced and eventually sold to the grid is to be maximized. This problem has been assessed in numerous article. In our work, we dissociated two objectives: the Annualized Cost of System and the amount of energy the plant has to import to supply a load.

This problem is solved by a Multi Objective Particle Swarm Optimization (MOPSO). The plant modeling is parametrized by 12 variables that represents the components size. This makes the modeling flexible and adaptable to a wide range of power plant setups by deactivating components. Furthermore each item can be modelled with a constant or a power-dependent efficiency.

The results depend heavily on the meteorological conditions. The study has been carried out for different sources (solar and wind), storages technologies (batteries, hydro-pumping, hydrogen) and on several locations, hence for different weathers. The algorithm successfully identified plants with a good autonomy and a low operating cost.

SDEWES2018.0534

An Exergy-Based Optimum Control Algorithm for Rational Waste Heat Utilization from the Flue Gas of Coal-Fired Power Plants

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Abstract

Waste heat available in the flue gas of power plant stacks is a major potential source of thermal power. In reclaiming and utilizing such amount of waste heat, additional pump or fans are used, which demand electrical power. At the same time while heat is recovered from the stack, the average flue gas temperature drops, resulting in the loss of natural draft. This requires power for an additional fan in the stack in order to compensate the required draft necessary for maintaining the design performance of the plant. Electric power has a unit exergy of almost 1 W/W. In contrary, the exergy claimed from the flue gas in the form of low-enthalpy heat has a much lower exergy. Therefore, from an exergetic point of view, the additional exergy required to drive pumps and fans must not exceed the exergy claimed from the stack. Therefore, although from the First-Law of Thermodynamics point of view, the net energy saved may be positive with an apparently high coefficient of performance value, the same generally does not hold true. This is a matter of determining the optimum amount of heat that can be claimed for a net exergy gain from the process, under variable outdoor conditions and the plant operations conditions. In order to facilitate this new exergy-based optimum control strategy, an analytical optimization algorithm was developed, which determines the optimum pump flow rate of the heat recovery system and how much fan power is required at the stack at dynamic conditions. Robust design metrics were established in order to assure peak net exergy gain if possible under dynamic conditions. One of the new metrics is the exergy-based coefficient of performance. For these purposes, the Second-Law of Thermodynamics and the Rational Exergy Management Model were extensively used. Parametric studies show that exergetic approach to the problem gives a realistic picture by showing that the amount of heat that can be optimally recovered is much different than the values obtained from classical economic and energy efficiency type of analyses. Results furthermore show that most of the waste heat recovery units in industrial applications, designed only based on the First-Law of Thermodynamics have exergy loss instead of gain and therefore, are responsible from more carbon dioxide emissions. It has been concluded that these applications must be retrofitted with the new exergy-based controllers for variable speed pumps and fans with optimally selected capacities.

SDEWES2018.0541

Cognition of Environment Around Power Transmission Lines with a Uav

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Abstract

Power transmission lines suffer a variety of failures including a gunshot damage, a bird-caging, internal/external corrosion, and excessive sag in that transmission lines are exposed to a variety of severe environments. The failures should be monitored and repaired on time along with accurate prediction of degradation to secure reliability and safety of transmission lines. For intelligent health monitoring and diagnosis of transmission lines, an unmanned aerial vehicle with novel sensors has been developed. This study present this smart unmanned aerial vehicle and a method to cognize power transmission lines and environments combining measured data from a global positioning system, an inertia measurement unit, and other sensors. Results of field tests demonstrate the performance of the proposed method and equipment. Considering inherent advantages of diagnosis and prognosis with an unmanned aerial vehicle, this study offer potential utility for the enhancement of existing operation and maintenance of power transmission lines.

Poster session 3

SDEWES2018.0017

Economy-Wide Effects of a Sustainability Pathway in the Pig Sector: a Case Study in Aragon (Spain)

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Abstract

Computable General Equilibrium models are widely used in the literature to analyse the global effects of certain events with economic repercussion. The intensity of these events is usually justified only in a vague way. But there are many situations where this intensity can be estimated with some degree of accuracy. An outstanding example is the application of new technologies to certain production processes. In this context, the economic impact of a replacement in the energy supply from classical to renewable sources on a specific economic sector are analysed. Specifically, this work focuses on the pig sector due to the relatively high off-grid energy use, taking Aragon (Northern Spain) as a case study because of the large size of the sector in this region. A partial equilibrium approach to evaluate this replacement is first addressed. This analysis provides the intensity level of the impact of the change. On the basis of these data, the impact of the energy replacement is simulated using a Computable General Equilibrium model developed and calibrated for the regional economy of Aragon. Findings show a slight increase in (pig) production and export, as well as the rebound effects linked to the increase in energy efficiency. Results are consistent and show the convenience of the approach.

SDEWES2018.0064

Influences of Magnesium Content in Rehydrated Mixed Oxides on Furfural Conversion

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Abstract

Hydrotalcites are widely studied double layered lamellar hydroxides. Their structure is derived from brucite [$Mg(OH)_2$], with partially substituted magnesium ions by trivalent cations bringing the positive charge to the structure and forming the “cation layer”. The positive charge is compensated by anions (hydroxyl, carbonates groups) of “anion layer” and anions in the interlamellar space also containing molecules of water. The layered structure collapses when exposed to elevated temperatures of calcination accompanied with water release and mixed oxide formation. The hydrotalcite layered structure can be reconstructed by rehydration. The calcination followed by rehydration typically increases basicity of hydrotalcites.

The acido-basic properties differ depending on Mg/Fe molar ratio. The effect of Mg/Fe molar ratio (1:1 – 1:10) on acido-basic properties, structure and textural properties of rehydrated mixed oxides was studied. These catalysts were compared in a model reaction of aldol-condensation of furfural with acetone.

The highest basicity was determined for the hydrotalcite with Mg/Fe molar ratio = 4:1. Catalytic activity comparison showed that the rehydrated mixed oxides with molar ratios 3:1-5:1 reached the total furfural conversion in 40 minutes of reaction (50 °C, 320 rpm, acetone/furfural molar ratio 10:1, 2 wt. % of the catalyst). The selectivity to the main products (FAc, F_2Ac) increased with conversion and reached approximately 65 % and 30 %, respectively. The catalysts were found to be stable in aldol-condensation because no leaching of Mg and Fe was determined by the products elemental analysis.

The Mg-Fe rehydrated mixed oxides are stable catalysts in the model reaction for the preparation of FAc and F_2Ac, and therefore they might find a potential application in substitution of conventionally used homogenously catalyzed syntheses by heterogeneously catalyzed processes.

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SDEWES2018.0218

Evaluation of Health and Wellbeing of Mediterranean Schools Through Air Pollutants Concentration Measurements

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Abstract

Indoor environmental quality in school buildings play an important role in health, wellbeing and students' learning outcomes. Different building standards require specific building design and systems to guarantee air quality conditions below guideline values. Air pollutants concentration in indoor spaces depends mainly on ventilation rate, number of occupants and their activity, and occupation profiles. Moreover, building design, furniture and claddings products, HVAC systems and urban location have a large influence in final performance. This paper presents the results of a monitoring campaign of 9 school buildings located in urban and rural areas in the south of Spain. Pilot schools were selected according to different building construction periods and design, building regulations and student ages. Pollutants concentration (CO, CO_2, $PM_{2.5}$, PM_{10}, TVOC and a set of specific aldehydes and volatile organic compounds) were monitored through active and passive measurement in 18 classrooms. The results pointed out that it is crucial to take into account the unique characteristics of the infant, primary, secondary and high-school classrooms to develop appropriate control strategies in order to reduce the exposure to indoor air pollutants and to minimize the adverse health effects. Also, exceedance of the limit value for air pollutant concentrations are associated to air pollutant sources, allowing the identification of design criteria and operating strategies for adequate indoor environmental performance.

SDEWES2018.0228

Membrane Distillation for Brine Treatment: Membrane Evaluation and Coupling with Solar Thermal Energy

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Abstract

Brine management is one of the major issues of desalination and to achieve zero liquid discharge. Among the different treatment solutions, membrane distillation (MD) is promising thanks to its potentially efficient coupling with renewable energy sources and because its performance is virtually independent of feed salinity.

In this study, a MD process was evaluated to treat water of high salinity (>50 g/L NaCl). Tests were performed in batch mode coupling a MD bench scale setup with a solar energy collector. The coupling configuration was optimized and five membranes made of polyethylene (PE), polyethersulfone (PES), polyvinylidene fluoride (PVDF), or polytetrafluoroethylene (PTFE), were tested in direct contact MD. Membranes were characterized through microscopy, contact angle measurements, and liquid-entry-pressure (LEP) tests. Synthetic water samples were used as representative brines.

Results from membrane characterization suggest the highest hydrophobicity of the oleophobic PE and the PTFE, with water contact angles over 130 degrees. The PTFE membrane showed also the highest LEP, with a value of 3.5 bar. Excellent rejection of total dissolved solids was observed and comparable permeate water fluxes were measured with all the membranes. Chemical analysis of the obtained water was carried out at the end of the tests, confirming that fresh water was of high quality. Overall, the correct integration of the coupled MD separation unit with solar thermal energy played a significant role in system performance due to heat losses and general inefficiencies. The system was optimized to be able to run by accumulating heat during and the day and exploit it during the hours without sun. An energy evaluation of this integration was performed. Our investigation showed that, by appropriate integration, MD may be powered by renewable energy also in less than ideal weather conditions, thus suggesting the potential as a stand-alone system to treat difficult water streams without intermittence.

SDEWES2018.0236

Experimental and Numerical Investigation on the Flow Noise Propagation Mechanism in Simple Expansion Pipelines Based on Synergy Principle of Flow and Sound Fields

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Abstract

As major equipment for implementing technological process, Shell-and-Tube Heat Exchangers are widely used in modern industries. Because the noise propagation in pipelines in Shell-and-Tube Heat Exchangers can't be ignored, it is a key point to investigate the transfer mechanism of sound energy in pipelines so as to develop a quiet environment. As a first trial this paper intends to reveal the propagation mechanism of flow noise in expansion pipelines from the flow and sound fields matching perspectives, develop the field synergy principle for sound energy transfer process and achieve high efficiency mufflers with low penalty of pressure drop.

Different from the traditional method, this study focuses on the flow and sound fields synergy principle to investigate the flow noise propagation mechanism in expansion pipelines. What's more, theoretical analysis, numerical simulation and experimental measurement methods are coupled together to investigate the pipeline noise propagation process. Based on the momentum and the energy equations in the sound field, the synergetic relationship between the flow and the pressure gradient fields is deduced, and the field synergy theory is established. The synergy of flow and sound fields are analyzed by the numerical simulation. The noise propagation in pipelines is measured experimentally. The synergy is verified by analyzing the simulation and experimental results of flow and sound fields. The results show that with the increase of synergy of the flow and sound fields, the work done by the fluid on the wall increases, which means the exchange of sound energy between the wall and the fluid increases.

In conclusion, the field synergy theory can be applied to the transfer process of sound energy. Through the analysis of velocity and pressure gradient fields, the synergy of the flow and sound fields can be obtained. Considering the effects of velocity on sound energy transfer process, the synergy between velocity and pressure gradient fields varies with different flow rates, which results in the difference of the silencing effect.

SDEWES2018.0240

The Social Discount Rate and the Economic Feasibility of Energy Retrofitting Measures of Public Buildings Located in Historical or Landscape Contexts

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Abstract

Social discount rate plays a strategic role in the evaluation of public investments, as it may influence, or even reverse, the resulting value of various indicators of economic feasibility, such as Net Present Value. Moreover, the choice of the social discount rate reveals whether and to what degree political institutions make public investments according to a fair use of natural resources as well as to the preservation of cultural heritage that will be left to future generations. The aim of this study is to analyse what effect setting a particular social discount rate has on the economic feasibility of investments made in the specific sector of energy retrofitting of public buildings that are located in contexts subject to historical or landscape constraints. A case study, consisting of a sample of energy retrofitting measures in southern Italy, has been analysed in terms of Net Present Values assessed by applying varying social discount rates according to those set in a few selected Italian regions and, also, in certain European countries. The findings reveal that, especially in cases where the economic feasibility is weak, the absence of national rules may result in controversial public decisions being taken, even within the same country, and also has diverse consequences on the attractiveness of high energy-efficiency investments and on the competition between local administrations in obtaining public funding, as well as on the quality of local cultural heritage.

SDEWES2018.0287

Evaluating Energy Access in Informal Settlements by on Site Survey. the Case of Reta Velha (Itaboraí) and Jardim Bom Retiro (São Gonçalo)

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Abstract

Poverty is a fact of life for millions of people, and energy poverty is both a cause and consequence of it. Almost 1.3 billion people (a fifth of the world's population) have no access to electricity and almost 2.6 billion use wood as their sole source of energy, particularly in rural areas including slums. In this framework, slums and their dwellings, poverty and energy poverty are fundamental factors to be deeply studied.

Improving the living conditions in slums is a crucial topic also addressed by the sustainable development goals, and access to modern energy services plays a fundamental role in achieving these specific goals.

The present research reports the results of a survey on two informal settlements in Rio De Janeiro: Reta Velha (Itaboraí) and Jardim Bom Retiro (São Gonçalo). A detailed analysis of energy poverty and energy access has been accomplished by questionnaires (carried out in about 500 households).

The questionnaire was based on a Multi-Tier approach: on the basis of the combination of multiple attributes of energy supply, higher tiers feature progressively higher performance, as the energy supply accommodates an increasing number of energy applications, and/or delivers improved user experience.

In particular, the questionnaire explored of the following themes: Dwelling features; Energy sources; Energy expenditure in relation with salary and willingness to pay; Energy data about Lighting, Food preservation, Cooking, Other home appliances, Water heating, Dwelling cooling and heating, Appliances for productive activities, Problems and criticalities related to energy access and management.

The most important critical issues deriving from the survey are that the electricity consumption is very high compared to the service they provide, and expenditures are generally disproportioned to the households' income. Further, outages and low tension compromise the reliability and durability of the electrical devices and the relationships between customers and the electricity distribution company. The settlements examined can be considered a samples that quite well represent the universe of favelas in Brazil, but not only. Many crucial characteristics are shared with that of the informal settlements in other contexts. For this reason, guidelines for improving energy access were structured.

SDEWES2018.0291

Atmospheric Carbon Abatement: Integration of Sugarcane, Biorefinery, Post-Combustion and CO2 Pipeline for Enhanced Oil Recovery

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Abstract

Due to pressure decrease, offshore oil production tends to reduce with time. This problem can be overcome by Enhanced Oil Recovery (EOR), which consists of injecting external agents, such as CO_2, to force oil expulsion. The main source of CO_2 for EOR comes from gas sweetening, though it is often not enough to the demand. An alternative is to import CO_2 from agro-industrial enterprises that currently release huge amounts of CO_2 in the environment. The present work assesses a plausible scenario where a large-scale sugar-cane based biorefinery conveys almost all its CO_2 emissions to be used as EOR agent. The biorefinery was simulated incorporating juice fermentation, ethanol distillation, biomass combustion, CO_2 post-combustion capture, CO_2 compression and transport through a 20" x 1000 km pipeline connecting sugar-cane processing region of São Paulo State, Brazil, to offshore oil fields in Santos Basin. Plant capacity was considered to be 1000 t/h of sugar-cane, with mass and energy integrations carefully adjusted for better utilization of resources minimizing losses and complying with environmental and economic requirements. Process was designed to be self-sufficient in power, also providing an excess of 100 MW of electricity for sale. Water consumption of 3,920 m^3/h was necessary to compensate evaporation and blow-down losses in the cooling tower system. The plant production of CO_2 was 699 t/h, where 94.3% come from combustion and the remaining from glucose fermentation for ethanol production. Assuming a recovery of 92% CO_2 from post-combustion capture, the plant was able to export 640.3 t/h (5.1 MMt/y) of CO_2. CO_2 compression was designed to allow the pipeline to dispatch the appropriate CO_2 flow rate achieving the correct EOR pressure at wellheads in oil fields. On economic grounds the plant represents 42% of the investment, the remaining being associated to the pipeline. Revenues came from ethanol production (19%), electricity sales (10%), avoided carbon emissions (4%) and EOR CO_2 (68%) which was supposed to be traded as equivalent produced oil. Several EOR oil-CO_2 ratios from 1 bbl/tCO_2 to 3 bbl/tCO_2 were investigated to evaluate the feasibility of the enterprise leading to the conclusion that long-term economic sustainability can be assured above 2 bbl/tCO_2.

SDEWES2018.0325

A Novel Paradigm for a Sustainable and Renewable Mobility: a Case Study for Taxi in Naples

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Abstract

This work presents an analysis of a novel sustainable mobility scheme based on the combination of electric vehicles and solar energy. In this system, the electricity produced by a field of photovoltaic collectors is used to supply electric vehicles, coupled to an electric storage system. The electric storage system allows one to limit the importation of electricity from the grid in order to supply the vehicle in case of poor solar radiation (early morning and late afternoon), by storing, instead, the excess electricity from the photovoltaic panels in case of high solar radiation. Therefore, this work aims at analysing from the thermoeconomic and environmental points of view this innovative system, in order to show the energy and economic advantages of the sustainable scheme with respect to the conventional technologies (i.e. the internal combustion engines producing a large amount of greenhouse gas emissions).The presented case study analysis refers to the taxis travel pattern of the city center of Naples (South Italy). For this case study, the taxis hourly power consumption, as a function of the kilometers driven per day was identified as well as the design of the site, where the taxis charging station, the photovoltaic panels field with the electric storage system and its connection with the national electric grid will be located. The dynamic simulation of this innovative system was performed by using the software TRNSYS. This tool allows one to dynamically predict the behavior of the analysed layout and also to carry out sensitivity analyses, by modifying system design parameters. The achieved results are strictly affected by the weather condition. During the summer, the system is almost gird-independent, so all the taxis are supplied by the photovoltaic panels and from the electric storage, whereas the energy surplus is sold to the national energetic grid. Conversely during the winter, solar energy covers a limited amount of the taxis energy demand, and the rest of the energy must be bought from the national electric grid. The economic analysis shows that for a photovoltaic surface area of 160 m^2, the single pay-back period is rather high, about 12 years, but it reduces to 6 years in case of feed in tariff per electricity. The reduction of the equivalent CO_2 emissions is about 67%.

SDEWES2018.0423

The Utilization Possibilities of Waste Polyurethane from Household Appliances

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Abstract

Polyurethane has a good insulation characteristic and good chemical resistance. Due to these two properties it represents an excellent insulation and lining material for refrigerators and freezers.

Experimental analysis of polyurethane (PU) waste material separated into several grain size classes was performed by the method of pyrolysis gas chromatography with mass spectrometric detection (Py-GC/MS) at various pyrolytic temperatures, namely at 500, 600 and 700 °C. Waste PU contains various groups of organic compounds (aromatic hydrocarbons, alkanes, alkenes, alkadiens, hydrazines, alcohols, aldehydes and ketones, compounds containing phenols, dioxines, carboxyl acids, ethers, additives, acetates, oxysulphates, alcanoates and contaminants) in various concentrations. The most important compounds include heterocyclic compounds of nitrogen, aromatic hydrocarbons, alcohols and alcanoates.

Organic compounds containing heterocyclic nitrogen, especially amines (e.g. n-ethylmorpholine, dimethylpiperazine, n,n-dimethylcyclohexanamine, n,n-dimethylbenzenmethanamine and others) belong to compounds with the highest concentrations in pyrolysates. These amines come from the catalysts during PU production. The experimental analysis found important differences in composition of amines and other compounds, in dependence on grain size composition. Unhomogenized samples produce the highest concentration of amines (> 40%) at the temperature of 500 °C. The temperature increase leads to the decrease of amines concentration. On the contrary, the sample homogenization leads to the significant increase of amines production. PU waste of grain size from 0.125 to 0.25 mm contained by 80% more amines with dominance of n,n-dimethylcyclohexamine. Concentrations in other grain size fractions were pronouncedly lower. The yield of amines is also influenced by temperature. Temperature increase (over 600 °C) leads to the decrease in amines concentration.

SDEWES2018.0426

Electricity and Quality of Life in Rural Areas of Colombia

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Abstract

A society that has access to electricity creates conditions to alleviate poverty, increase social protection and raise its standard of living. Recently there has been an interest in the field of electrification and its effect on the quality of life. Empirical evidence has demonstrated the relationship of effect and causality between energizing and improving quality of life. Recent research on the subject exposes the risks to health, the damages in the education and the challenges of the productivity of those societies that suffer energy poverty.

The intuitive explanation of the impact generated by the energization is the improvement in the levels of health, education, productivity and income. It is understandable that an increase in education will lead to an increase in income, but it is also true that a greater amount of income allows a household to seek better educational conditions. Due to these bidirectional causalities, the estimation of the relationships required an econometric model that takes into account the problems of endogeneity: model of simultaneous equations of three stages with least squares (3SLS).

In the Colombian case, some studies have been carried out to measure the effect generated by the energization in the national territory. However, most of these have been focused on technical and economic assessment, but they do not evaluate the subsequent changes generated when the projects start-up, and do not take into account quantitative methods to analyze social, economic and environmental variables.

According to the politico-administrative division of Colombia, dispersed rural areas are distributed in 1,101 municipalities, 20 Non-Municipalized Areas, and 56 National Natural Park with continental area. Additionally, approximately 4% of the Colombian population is not connected to the national grid and in the dispersed rural areas of Colombia; this percentage is about 15% of the total population.

Consequently, this work analyzed the effect of energization on income, education, health, and employment productivity in the dispersed rural areas of Colombia. The cross-sectional data for the test were obtained from the Colombian National Agriculture Census, which were conducted by the National Administrative Department of Statistics and the Energy Mining Planning Unit of Colombia. Furthermore, an econometric model was used to represent the endogenous behavior of the problem, i.e. a simultaneous equations model of three stages with least squares. The regression results showed the access to electricity like a positive impact in the case of study. This effect was observed directly through the intermediate effects of the levels of education, health and agricultural productivity.

SDEWES2018.0469

Visible Light Induced Photocatalytic Degradation of Phenol Using TiO2-Al2O3-RGO Composite Catalyst

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Abstract

Photo-catalytic degradation is one of the promising curative methods for environmental pollution. The recent research focus is on the development of visible light active material to utilize visible light (i.e. 48% of solar spectrum). In this work, Titania was incorporated with Alumina and Reduced graphene oxide (RGO) which is a TiO_2 based visible light photocatalyst. The novel combinations of these three materials were prepared by the one-pot sol-gel technique with optimization of TiO_2/Al/RGO ratio. The nanoparticles were characterized by XRD, SEM, FTIR, BET and EDX. The nanoparticles have surface area of 133.5 m^2/g which is higher than that of TiO_2 RGO (74.3 m^2/g) and TiO_2 (55.1 m^2/g). SEM and EDX results evidenced that Titania and Alumina are uniformly distributed over the sheets of RGO. The photo-activity of this catalyst was investigated over Phenol degradation up to 200 ppm using UV as well as visible light. Also the effect of various parameters viz. initial pollution concentration, catalyst loading and pH on degradation was explored. It was found that there is no general optimum condition for degradation. For each case the optimum condition was unique. It was also observed that as the initial pollutant concentration was increased, the time required for same percentage of degradation was increased. Experiments also shows that with increase in catalyst loading initially degradation was increased to an optimum point and on further addition it was decreased because of shadowing effect. Study of reaction kinetics and catalysis mechanism was done and various kinetic parameters were evaluated. The catalyst showed enhanced degradation of 96.2% and 82.6% at pH 5 under UV and visible light respectively with 5% of RGO and 10% of Alumina(gamma) in TiO_2 (Anatase). Degradation obtained by pure TiO_2 was 72% with UV and 53% with Visible light whereas TiO_2 RGO gave 84.7% with UV and 77.3% with Visible. It was found that only adsorption and photolysis was giving degradation of 12.2% and 4.6% respectively. Catalysts were characterized after Photo-degradation which showed no change in physio-chemical property.

SDEWES2018.0472

Conventional Versus Ultrasonic Biosorption of Methylene Blue Dye Onto Fava Bean Peels

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Abstract

The emerging environmental concerns have urged much interest in the valorization of food and agricultural wastes as biosorbents for water treatment. In Egypt, the high consumption of Fava Beans (Vicia faba) as a pivotal food component led to the disposal of abundant Fava Bean Peels (FBP) wastes. The present work investigates the potential of using FBP as biosorbents for the removal of Methylene Blue (MB) dye from aqueous solutions through developing a viable and efficient sorption process. In this regard, biosorption was conducted using both conventional and ultrasonic-assisted shaking, under different operating conditions of contact time, solution pH, adsorbent dose and initial concentration of the dye. For both processes, linear increase in uptake capacity and hyperbolic increase in removal efficiency were exhibited with increasing the initial dye concentration, however, the removal efficiency increased exponentially with increasing the adsorbent dose. Ultrasonication had no effect on sorption capacity but remarkably enhanced sorption rate by up to four times relative to conventional shaking. Sorption kinetics was best described by the pseudo-second-order kinetics model, whereas sorption equilibrium followed a Langmuirian type behavior with a maximum sorption capacity of 140 mg/g at room temperature. The effect of the different operating conditions on sorption capacity was analyzed using multiple linear regression model. Characterization of FBP pre and post-biosorption using Scanning Electron Microscopy (SEM) and Fourier Transform Infrared Spectroscopy (FTIR) revealed the surface morphology and active functional groups on FBP whose chemical structure was not altered upon ultrasonication. Surface area, pore volume, and pore size distribution were also determined by Brunauer, Emmet, and Teller (BET) analysis. In conclusion, FBP could be successfully utilized as a low-cost sustainable biosorbent for the removal of MB and potentially other dyes and heavy metals from wastewater. Ultrasonic-assisted biosorption could be proposed as a viable efficient alternative to conventional sorption since it yields the same sorption capacities but with significant reduction in operational times.

SDEWES2018.0477

Numerical Investigation of Co-Firing Biomass Under Oxy-Mild Combustion

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Abstract

Oxy-fuel combustion is an attractive technology for the mitigation of CO_2 emission from utility boiler. Nowadays, negative CO_2 emission concept attracts increasing concern. Biomass is considered to be CO_2-neutral. In this work, co-firing of biomass and coal was applied to achieve below-zero CO_2 emission.

MILD (moderate and intense low-oxygen dilution) combustion, which has high thermal efficiency and the advantage of NOx reduction, has become a hot point in recent years.

In this paper, FLUENT 17.0 was used to simulate the co-firing of coal (Guasare coal) and biomass (olive waste) under traditional and oxy-fuel conditions respectively. EDC model with J-L four-step reaction was adopted to consider the turbulent chemistry interaction behavior. First, the model validation was conducted in the IFRF furnace NO.1 under traditional condition, and the results fitted well with experiments. Then combined with the characteristics of oxy-MILD combustion and co-firing biomass, the further research was carried out under the conditions of 10%, 20% and 30% biomass fraction respectively. The effect of working conditions on temperature field, rate of entrainment, burnout rate as well as NOx emission were discussed. Finally, the micro characteristic of the simulation result, Damköhler number, was further analyzed.

The results showed that MILD combustion in traditional mode has a higher peak temperature, reaching 1788 K. While under oxy-fuel conditions, it has a milder temperature field with a lower peak temperature, only 1702 K. The peak temperatures at 10%, 20%, and 30% biomass mixing ratios are 1690K, 1683 K, 1674 K respectively. At the outlet, the NOx concentration decreased significantly.

Meanwhile, as for the micro characteristics, with the increase of biomass fraction, Damköhler number gradually decreased, which meant a more moderate combustion.

In a word, MILD combustion can also be well achieved through co-firing under oxy-fuel combustion.

SDEWES2018.0483

Nutrient Optimization Facilitating Phytoremediation for Heavy Metals by Energy Crops

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Abstract

Phytoremediation is highly regarded as an alternative method for soil and groundwater pollution remediation globally. Native plants are preferred to phytoremediation for reducing ecological impact. Two proven native plants, Taiwanese chenopod and Napier grass, are investigated for Cd^{3+}, Cr^{3+}, Cu^{2+}. Biomass yields of Napier grass are from 3.53 to 4.28 times more than the ones of Taiwanese chenopods. Nutrient addition of Taiwanese chenopods can raise the biomass yields 1.26 to 2.28 times more than the controls. Cu^{2+} uptake for Napier grass was 42.10 for controls, and the Cu^{2+}uptakes were increased from 68.63 to 82.19 mg/kg by nutrient additions. Cu^{2+}uptake for Taiwanese chenopod was 265.30 mg/kg for controls, and the Cu^{2+} uptakes were increased from 337.45 to 377.64 mg/kg by nutrient additions. Cr^{3+} uptake for Napier grass was 14.65 mg/kg for controls, and the Cr^{3+} uptakes were increased from 38.20 to 44.36 mg/kg by nutrient additions. Cr^{3+} uptakes for Taiwanese chenopod were from 55.20 to 64.15 mg/kg for controls, and the Cr^{3+} uptakes were increased from 337.45 to 377.64 mg/kg by nutrient additions. Cd^{3+} uptake for Napier grass was 2.57 mg/kg mg/kg for controls, and the Cd^{3+} uptakes were increased from 3.93 to 4.81 mg/kg mg/kg by nutrient additions. Cd^{3+} uptake for Taiwanese chenopod was 13.43 mg/kg for controls, and the Cd^{3+} uptakes were increased from 17.27 to 20.11 mg/kg by nutrient additions. Nutrient additions are shown to raise uptakes for three heavy metals, especially for Cd^{3+}. This study demonstrated that nutrient optimization facilitating phytoremediation by increasing biomass yields. And yielded biomass will be available for bioenergy application.

SDEWES2018.0491

Synergistic Effects of Biomass and Polyurethane Plastic Co-Pyrolysis on the Soot Formation at High Temperatures

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Abstract

Soot can be largely generated as a toxic pollutant, during the air-lean operating of high-temperature incineration of solid waste, including biomass and plastic waste. The main objective of this study is to demonstrate the synergistic effect of biomass and plastic waste co-pyrolysis on soot formation at high temperatures (1100-1250 °C). The effect of temperature, biomass type, and co-pyrolysis ratio on the yield, morphology, composition, and reactivity of soot particles are studied. Results show that the measured soot yield as well as the particle size during co-pyrolysis is smaller than expected. This synergistic effect degree increases with the increase of biomass ratio (0~50 wt.%) and the decrease of pyrolysis temperature. Wood co-pyrolysis presents a stronger synergistic effect on soot yields than straw co-pyrolysis. The synergistic effect on the reactivity of soot oxidation depends on biomass ratio. At 10 wt.% straw co-pyrolysis ratio, the measured soot oxidation reactivity is lower than theoretical one; while the straw co-pyrolysis ratio increase to 50 wt.%, the measured one is much higher than theoretical one because of the catalysis from potassium chlorine. By comparison, because the potassium in wood ash is much lower than that in straw ash, the synergistic effect of wood co-pyrolysis on soot oxidation reactivity is weak.

SDEWES2018.0502

Evaluation of the Influence of Oil Physicochemical Characteristics and the Environment in the Degradation of Spills in Rivers, Using Adios (Noaa)

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Abstract

According to the National Environmental Licenses Authority –ANLA, between 2004 and 2017, there were around 6.300 oil spills in Colombia, 40% of which affected freshwater bodies. The analysis of the behavior of oil spills scenarios using mathematical models is fundamental to the design of effective contingency plans, however, in the country, the licenses fees limit its use.

In this paper, the degradation of oil spills sceneries in a sector of the Magdalena River (Colombia) was analyzed using stochastics models in the free software Automated Data Inquiry for Oil Spills –ADIOS. Time-varying profiles were obtained for the percentage of the oil evaporated, dispersed, remaining; the percentage of water in the emulsion, changes in density and viscosity. The values of these response variables were analyzed using ANOVA analyzes, which allowed to identify the oil type, temperature, and wind speed are the most influential characteristics in the oil spill degradation processes.

SDEWES2018.0514

LCA of a Semi-Batch Reactor and a Semi-Batch Recycle Reactor to Produce Polyamines

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Abstract

Polyamines are applied as curing agents for epoxy resins, to produce functionalized polyamides and chelating agents. These compounds are a valuable substrate for the synthesis of several fine chemical additives. Triethylenetetramine (TETA) is an additive for asphalts, fuels and textile fibres. Moreover, they are market products as surfactants and corrosion inhibitor.

We investigated the unselective synthesis of polyamines through alkylation of 1,2-dichloroethane with a diamine in a standard semi-batch reactor (SBR) as well as in a semi-batch recycle reactor (SBRR) (Figure 1), aiming at increasing TETA productivity and showing that the latter leads to a selectivity of 70 % of TETA compared to the 50 % obtained with SBR. The main purpose of the industrial research is to develop processes that lead to the production of TETA with the highest concentration achievable. However, information lacks regarding the environmental burdens of the synthesis processes.

Life cycle assessment (LCA) calculates the energy and material consumptions, the quantity and type of emissions and other important factors all related to the entire life cycle of a product, a process or a service (from the extraction of raw materials to the distribution / use / maintenance / disposal / recycling). We apply LCA to assess the impact of a lab-scale plant that produces enriched air and we optimized the process concerning the environmental burdens. Here we study and compare the impacts of SBR and SBRR processes to synthesize TETA. The SBRR configuration needs more units than the SBR one, indeed there is an additional reboiler (and consequently its heat/electricity) and a Claisen condenser (with a cooling water flowrate). On the other hand, SBRR reaches better TETA selectivity. In this work, we want to investigate these contrasting contributions using the LCA analysis tool to evaluate and compare the two processes, for the first time.

We select 1 kg of TETA as functional unit and thus we correct the impacts calculated by the selectivity of the two processes. A Monte Carlo simulation estimate the confidence interval. SBRR configuration is environmentally favourable to the SBR.

SDEWES2018.0579

Hydrogen Production Using Electrodeposited Pd on Directly Grown Graphene/Stainless Steel (Ss 304) Substrate

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Abstract

Palladium/graphene nanocomposites/clusters are widely used as an electrodes by many researcher's for various applications. Palladium (Pd) is a good candidate to replace metal oxides, because H_2 molecules are selectively adsorbed onto the surface of Pd by dissociation into hydrogen atoms ($H_2 \rightarrow 2H$), and diffused into the interstitial sites of Pd structure. In this study,

In this work we have used stainless steel as a substrate. It exhibits limited resistance to corrosion and wear, which leads to degradation of the material quickly. To overcome this, graphene was grown directly onto the stainless steel (SS304) substrate by atmospheric pressure chemical vapor deposition under, $H_2/Ar/CH_4$ environment. The sample is kept at high temperature during the entire period of growth. Then palladium was electrodeposited on the directly grown graphene/stainless steel substrates.

In this study, it is possible to grow continuous and high quality graphene directly on stainless steel substrate without nickel as a buffer layer using CVD. Electrodeposited palladium over the graphene/stainless steel substrate was confirmed by Raman and XPS spectra. The presence of few layer graphene enhances the corrosion resistance without altering the properties of stainless steel. The results of systematic study of directly grown graphene on stainless steels and Palladium/graphene/stainless steel nanocomposites for electrocatalytic hydrogen production are discussed. A nexus between the palladium catalyst and the graphene is believed to yield high efficiency.

This research was supported by the Nano·Material Technology Development Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Science and ICT (2016M3A7B4904328).

SDEWES2018.0581

Development of Single Bifacial Electrode with the Photoelectrochemical Anode and Electrochemical Cathode for Water Treatment

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Abstract

The electrochemical advanced oxidation processes (EAOP) is one of the currently popular technologies because of simple devices and high treatment effect. This process has been extensively studied in the development of electrode with low-cost materials and high efficiency for water treatment. Hydrogen peroxide(H_2O_2) is an active oxygen and generated at a low voltage. Hydrogen peroxide produced by the reduction of oxygen can be decomposed by UV to generate OH radicals and improve the resolution of pollutants. In this study, we developed the single bifacial electrode with the photoelectrochemical WO_3 anode for generating oxygen and electrochemical CNT cathode for H_2O_2 production. The efficiency of the electrode was investigated 25 uM phenol degradation and H_2O_2 production according to the presence or absence of light and oxygen. The WO_3 electrode was composed of aggregates of 50-80 nm, 1.5 µm height and CNT electrode were composed of 50–60-nm-thick tubular carbons. Phenol oxidation of PEC (Photoelectrochemical process) and O_2 purging were more 10 times than that of other conditions (PEC, EC (Photoelectrochemical process) + O_2 pursing, EC). p-PCA(p-chlorobenzoic acid), the indirect indicator of OH radicals, was rapidly degraded at PEC+ O_2 pursing and PEC. Electrodes on PEC indicated a similar regardless of the presence and absence of oxygen and produced 2 umol H_2O_2.

SDEWES2018.0583

Interdependences Among Gas and Power Systems: a Platform for the Techno-Economic Analysis of EU Scenarios

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Abstract

The poster presents a development of the techno-economic modelling platform of the power and gas system of EU countries. The specific purpose of this platform is to simulate the interactions between power and gas systems and the propagation of effects among different geographical areas under scenarios of shortages of gas supply, extreme weather events inducing peak demands of natural gas. Our final scope is to check the functioning of critical infrastructures (e.g. specific groups of gas fired power plants) whenever shortages and restrictions to the gas supply may affect different routes in Europe.

The platform shares the architecture and the same modelling software (PLEXOS) with the JRC European power dispatch model and builds on large experience in simulating gas crises and the EU gas transmission system using mass balance model and a hydraulic model. The innovative techno-economic nature allows obtaining, as result from the simulations, impact on prices, according to the current market constraints of different EU regions.

The default stylized topology implements a one node per country network. Data from the European Network of Transmission System Operators (ENTSO-E for electricity and ENTSO-G for gas) are used to define basic characteristics for interconnection and the generation technologies for electricity supply in each region. The actual one-node-per region structure is the topology designed for the baseline version of the platform. Each region can then be replaced by a corresponding portion with a higher detail, in order to provide further insights for policy support purposes.

Our reference scenario is designed to reproduce the system in 2016. This has been tuned to check also the economic assumptions and cost data for all the intermediate steps of the gas transmission, storage, regasification and extraction in indigenous production of the EU countries. The current reference PLEXOS dataset allows exploring the gas-electricity interactions with an hourly time granularity. The modelling platform aims at combining a large scale geographical coverage (EU-wide) with a diversified level of detail to study future scenarios useful for analyses of the security of gas and electricity supply.

SDEWES2018.0601

Development of a Dashboard for the Management of an Activated Sludge Treatment Plant Using Analytic Hierarchy Process

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Abstract

Wastewater treatment plant is a structure that needs a precise and rigorous control to obtain satisfactory results of purification efficiency, low cost energy and discharges compatible with pollution standards. This paper present a method for developing a dashboard to manage control and monitor the operation of a wastewater treatment plant and to make the right decisions for the situations encountered, based on daily variation of different criteria of decision judged necessary for the estimation of the biological treatment process, that is: energy consumption,the respect of the environment,purification efficiency and the degree of pollution of the income wastewater. A data analysis was performed, combining two methods: Analytic Hierarchy Process (AHP), as a pairwise comparison tool for all observations, and Principal Component Analysis (PCA) for the weighting of the criteria considered. The dashboard elaborated allows the classification and the estimation of the performance of different strategies of management of wastewater treatment plant based on the importance allowed to each decision criteria.The result is a tool for an efficient management of wastewater treatment plant.

SDEWES2018.0613

CH4-CO2 Replacement in Natural Gas Hydrates and Membrane-Based CH4 Recovery: Energy and Environmental Evaluation

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Abstract

Currently, natural gas hydrates are considered one of the most important future unconventional energy resources. This paper deals with gas hydrate exploitation and the methane recovery. It proposes and analyzes the CH_4-CO_2 replacement in the hydrate phase and pure methane collection through the use of membrane-based separation. The investigation uses a 1 L lab reactor, in which the CH_4 hydrates are formed in a quartz sand matrix partially saturated with water.

CH_4 is subsequently dissociated with a CO_2 stream supplied within the sediment inside the reactor. An energy and environmental analysis was carried out to prove the sustainability of the process. Results show that the process energy consumption constitutes 4.75 % of the energy stored in the recovered methane.

The carbon footprint of the CO_2-CH_4 exchange process is calculated as a balance of the CO_2 produced in the process and the CO_2

stored in system. Results provide an estimated negative value, equal to 0.004 moles sequestrated, thus proving the environmental benefit of the exchange process.

SDEWES2018.0623

Scaling Bottom-Up Energy Access Data Collection: a Proof of Concept in Rural Nepal

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Abstract

The momentum behind Sustainable Development Goal 7 underlines a global consensus that universal access to modern energy services is central to the international development agenda. Geospatial analysis has proven itself a crucial tool for energy planning, however, lack of quality input data often impedes application of modern spatial planning tools.

The objective of this paper is to discuss a proof of concept for scaling primary survey data by leveraging remotely sensed population datasets, through a case-study of seven rural municipalities in Province 1 of Nepal.

Recently collected household survey data (n = 400 in each municipality, of total 7 municipalities) was combined with OpenStreetMap and WorldPop datasets. Using electricity demand, current access and settlement locations, we classified each settlement by the typical electricity supply technology and assign the predominant cooking technology, as well as determine its median current and future electricity demand. Finally, we determined the total number of households per settlement and, consequently, extrapolated its total current and future residential electricity demand.

A low-barrier web-map was developed that enables municipalities to rapidly assess their energy access situation (https://setupelz.github.io/scalingsurveydataprototype/#10/26.8136/87.1035). Settlement level information on household electricity demand is provided.

The webmap shows that grid connection is more common in the Plains rather than in the Hills regions, where mini-grids and SHS are predominant. These differences are reflected in current electricity demand, with grid connected settlements reporting higher median values. Interestingly, when looking at suppressed/future demand the relation reverses, with mini-grid and SHS prevalent settlements reporting higher median values. As for cooking technology, the heterogeneity across settlements is much lower, such that unimproved cook stoves stand out as the predominant technology almost everywhere.

The availability of data necessary for making energy planning decisions remains a major obstacle for energy planners in developing countries. Combining primary survey data with remotely sensed population datasets can be a cost-effective approach to overcome such stumbling blocks. Making such data accessible in intuitive and “interactive” ways that do not require GIS capacity building in the short-midterm is then crucial in countries where such abilities are still being developed.

SDEWES2018.0627

An Efficient and Spectrophotometric Determination of Paracetamol and Caffeine in Tablets Based on Chemometrics

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Abstract

The aim of this paper was to develop a spectrophotometric method for efficient and simultaneous determination of paracetamol and caffeine contents in the synthetic binary mixture using chemometric methods. The partial least squares regression and artificial neural network was applied for the content estimation. In the partial least squares method, the matrix of absorbance in the range of 200-400 nm represented X-block (26×201), while the Y-block (26×1) represented the concentrations of the observed analyte. The optimal components number in the PLS-1 models for COF and PCT was 6 and 4, respectively. The absorbance values were used as the inputs, while the concentrations of the analytes were defined as the outputs during the design of artificial neural network. The optimal neural network belonged to the multilayer perceptron that had the 25 neurons in the hidden layer. The log-sigmoid and linear activation functions were used in the hidden and output layers, respectively, for data processing. The developed methods were successfully applied for determination of paracetamol and caffeine contents in the commercial pharmaceutical formulation. Based on the statistical parameters, it can be concluded that the partial last squares method was a more superior method for determination of the content than artificial neural network.

SDEWES2018.0632

Transition Index as a Tool for Urban Expansion Environmental Assessment – Wroclaw and Poznan Soil Sealing Case Study

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Abstract

Irreversible changes of land functions related to urban sprawl are well known source of many environmental problems. There are green area destroying, soil sealing, landscape water retention lowering, decreasing microclimate inertia for heat waves, natural habitats fragmentation, water and air pollution and many others. The common problem is comparison and valuation of such effects in cities with different residential area demand and different supply of neighboring land with low environmental value. This can be overcome by considering instead of absolute area consumed by city, the ratio of percentage consumption of high natural value land to percentage consumption of all land available to urban sprawl. Such constructed ratio called Transition Index can be compared irrespectively to city size, land use and time, giving opportunity to spatio-temporal assessment of environmental problems awareness among city planners and law makers. Case study analysis were performed for two big polish cities: Poznan and Wroclaw, where rapid population growth is connected with high consumption of neighboring agricultural areas for residential purposes. We used detailed agricultural maps for soil valuation and sattellite images for city area mapping for 1968-2017 period. Despite of huge differences between selected cities, we noted that growth accelerated by need of EU funds absorption wasn't paid by much higher preferential land consumption for urbanization and connected soil sealing of high agricultural value soils.

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School of Mechanical Engineering, University of Campinas - UNICAMP
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Shandong University of Technology
Shanghai Jiao Tong University
Silesian University of Technology
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Brno University of Technology - VUT Brno
Technical University of Denmark
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The British University in Egypt
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The Hong Kong Polytechnic University
The Scientific and Technological Research Council of Turkey (TÜBİTAK)
The Szewalski Institute of Fluid-Flow Machinery of Polish Academy of Sciences
The Szewalski Institute of Fluid-Flow Machinery Polish Academy of Science
The Szewalski Institute of Fluid-Flow Machinery, Polish Academy of Sciences
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Tokyo Institute of Technology
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University of Belgrade, Faculty of Architecture
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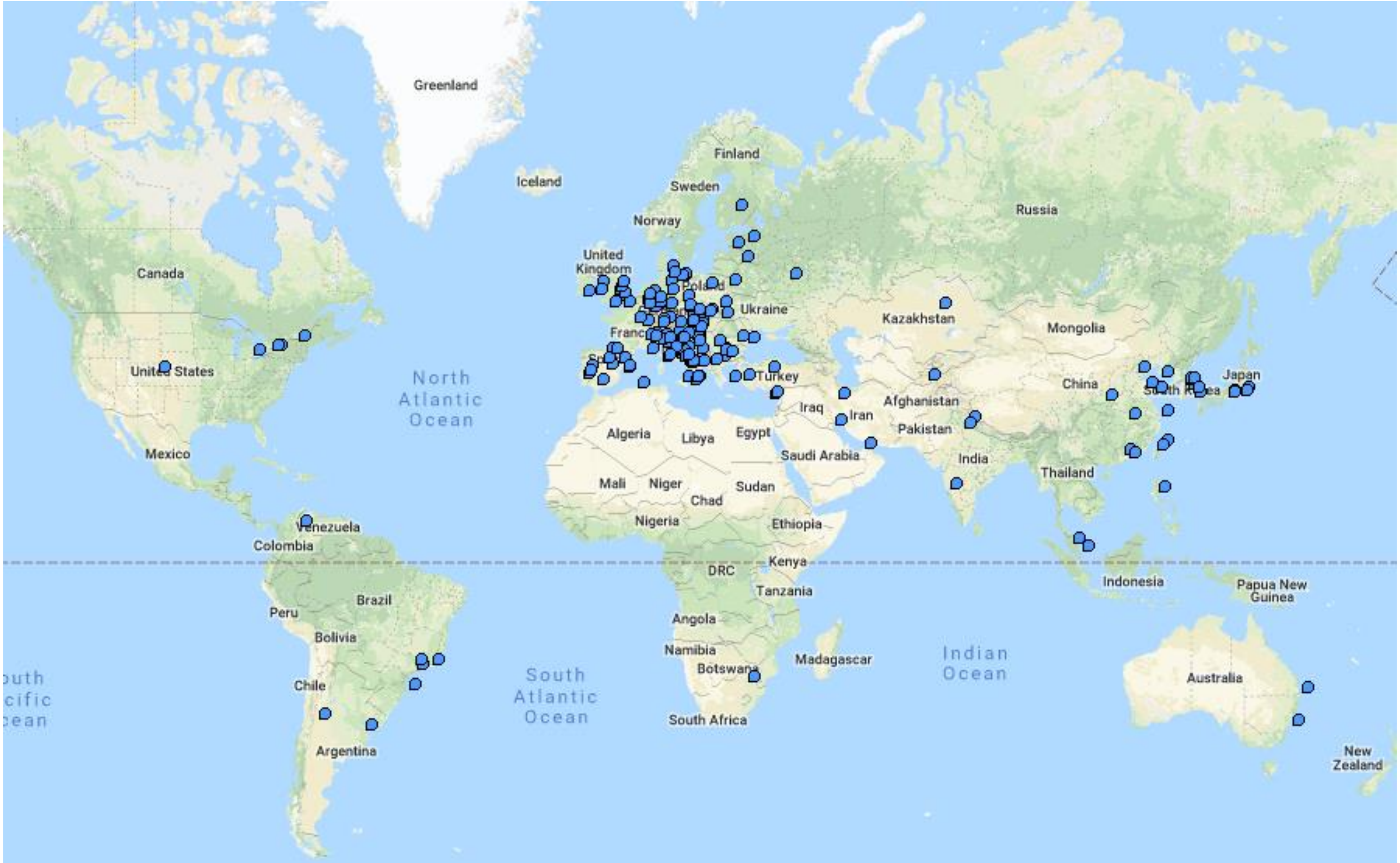

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