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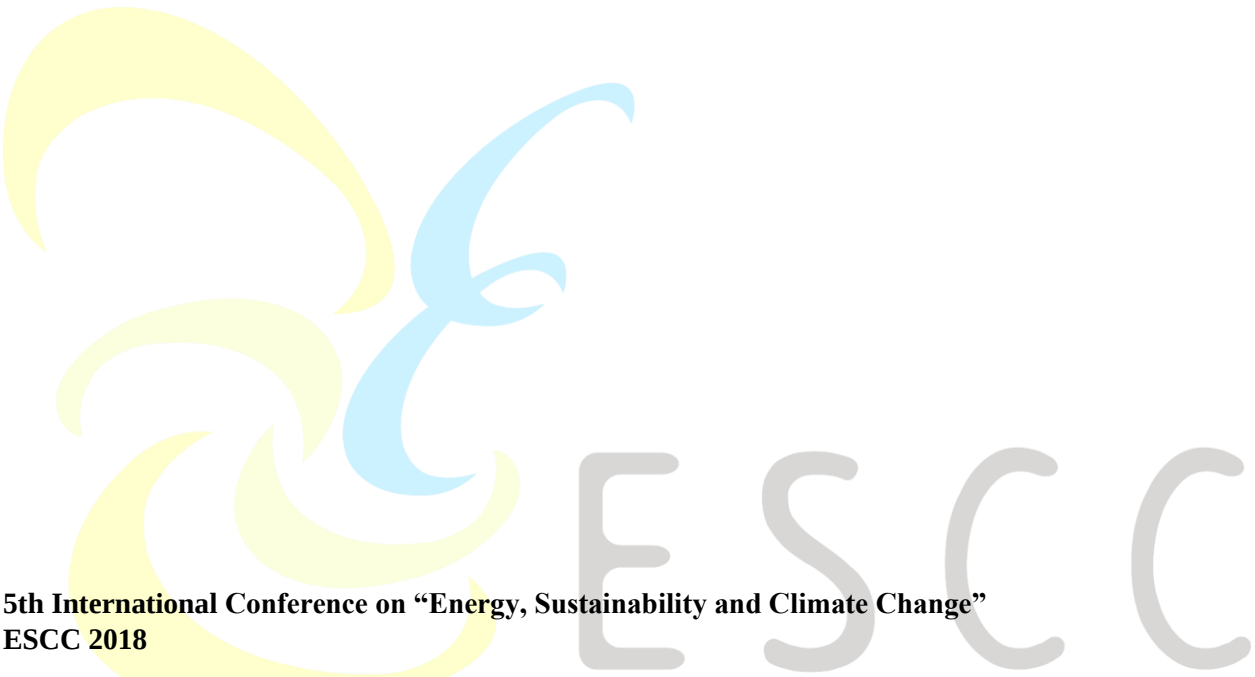

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Eleousa Zygouri

Table of Contents

Integrated Design Considerations for Net Zero Energy Solar Communities: Canadian Case Studies

Caroline Hachem-Vermette, Faculty of Environmental Design University of Calgary, Calgary, Canada
Email: caroline.hachem@ucalgary.ca

Keywords: Integrated Approach, Solar Access, Solar Technologies, Neighborhood Design

The design of new communities often lacks an integrated approach, with buildings designed without much consideration for energy implications of their urban and environmental context, including site layout, their setting within this site and their relation with other neighboring buildings. For instance, in mixed-use neighborhoods, high-rise buildings may be designed right next to low-rise buildings, resulting in negative effect on solar access and on the feasibility of integrating solar technologies, and consequently on the overall energy performance of the neighborhood. While this may be unavoidable when erecting new buildings within existing neighborhoods, such negative effects can be avoided or mitigated in the design of new neighborhoods, by the implementation of an integrated design process.

This presentation includes design considerations for an integrated design of solar, net zero energy communities highlighting the interactive nature of various design parameters to improve the energy performance of these neighborhoods. These considerations are illustrated through practical design examples of different neighborhood scenarios and individual buildings, based on extensive studies and analysis of energy performance of a wide spectrum of buildings and neighborhoods. The examples fall under two general categories – design at the neighborhood level, and design at the individual building level. Neighborhood design is illustrated by examples of homogeneous residential neighborhoods consisting of 2-storied housing units and of a mixed-rise neighborhood. Design of individual buildings focuses primarily on design of the envelope – consisting of roof and façades – for maximizing energy generation potential, as a function of height and relative position to adjacent buildings. In addition, opportunity of thermal storage is presented as a stage to achieve net zero energy communities.

Moving Towards New Energy Era

Andreas Poullikkas, Cyprus Energy Regulatory Authority, Nicosia, Cyprus
Email: andreas.poullikkas@eecei.cut.ac.cy

Keywords: Energy System, Power System, Energy Economics, Renewable Technology

The energy industry is one of the few industrial sectors, which affect prosperity of every sphere of economic and social life and exert a direct influence on general technological progress. Much of the worlds energy, however, is currently produced and consumed in ways that could not be sustained. The need to control atmospheric emissions of greenhouse and other gases and substances will increasingly need to be focused on efficiency, cost and sustainability in energy production. Renewable energy sources (RES) can help provide for our future needs by harnessing abundant, naturally occurring sources of energy, such as the sun, the wind, and biomass. Effectively harnessing these renewable resources requires careful planning, advanced technology and new optimisation tools. The plenary talk will cover the developments of future sustainable energy systems and strategies towards 2050. The European Union's energy policy will be discussed, the main long-term goal of which is the conversion of the existing energy system, now heavily dependent on fossil fuels, to a sustainable energy system based on differentiated energy sources of higher energy efficiency. Recent research work regarding the development of advanced simulation tools for the techno-economic optimisation of the future sustainable energy systems will be discussed. An optimum scenario leading to hydrogen economy will be presented and the relevant energy cost towards 2050 will be discussed and justified through various examples of the use of sustainable energy technologies.

Robust Optimisation as a Response to Uncertainties in Energy Use

Gülgün Kayakutlu, Istanbul Technical University, Energy Institute, Istanbul, Turkey
Email: kayakutlu@itu.edu.tr

Keywords: Robust Optimisation, Uncertainty Handling

Extended investment in renewable energy use increases uncertainties in the energy world. Demand and price have always been the major concerns of the forecasting experts, but now, the resource availability is in the set of unknowns. Furthermore, with the widespread of the micro-grids and smart cities, heterogeneous demand smoothing, fair energy services are only possible with solutions for the uncertainties. General solutions for the growing uncertainties are provided by using the stochastic or meta-heuristic approaches. However, random data generated in those solutions are not reliable unless the distribution is not exactly known. If Robust Optimisation is allowed to capture the randomness, the issues can be handled to an extent. Robust counterpart of a minimization problem can be found by taking the best and worst limits of the dual of the problem. Hence, Robust Optimisation studies the set of possible limit scenarios on the dual constraints in order to find relevant optimum solution. Solutions proposed by applying the Robust Optimisation has less data dependence and solves the computational complexity problem. Yet, there is an important problem of defining the confidence limits and minimum or maximum worst cases if no historical data is found. Though some researchers prefer to find the exact solution with 100% confidence limit, it is not realistic in the market. Besides wind speed fluctuations or solar shining may show wide ranges on the average {-40%, +40%}. Therefore, stochastic methods are unavoidable components of Robust Optimisation. This paper will present Robust Optimisation definitions in different uncertainty cases with a varying use and will try to discuss the benefits of using this solution in the energy field. Giving importance to the Robust Optimisation models will allow the improvement of energy market models which are yet only handled as deterministic approaches.

Optimization, Modeling, and Data Sciences for Sustainable Energy Systems

Panos M. Pardalos, University of Florida, Gainesville, Florida, USA
Email: pardalos@ufl.edu

Keywords: Sustainable Energy, Optimization, Data Sciences

For decades, power systems have been playing an important role in humanity. Industrialization has made energy consumption an inevitable part of daily life. Due to our dependence on fuel sources and our large demand for energy, power systems have become interdependent networks rather than remaining independent energy producers. This talk will focus on the problems arising in energy systems as well as recent advances in optimization, modeling, and data sciences techniques to address these problems. Among the topics to be discussed are emission constrained hydrothermal scheduling, electricity and gas networks expansion, as well as reliability analysis of power grid.

Ultralow Power Computation for the Internet of Things (IoT)

Jose C. Principe, Department of Electrical & Computer Engineering, University of Florida, Florida, USA
Email: principe@cnel.ufl.edu

Keywords: Pulse Based Computation, Iot, Ultra-Low Power

The exponential advances in our information society have been fueled by computers. Our current model of computation is digital and based on the Von Neumann computation model. We are currently using the same computation paradigm in embedded intelligent systems up to cloud computing. Computers are taking about 3% of the world energy usage, but in the next 10 years this number will increase 5 fold! The IoT market is estimated to explode in the next 10 years with about 200 billion devices connected to the web. Computation for IoT is drastically dependent upon available power, so the interesting question is: can we create a new ultralow power computation paradigm for IoT? This talk will present an overview of alternative forms of computation and their possible applications in IoT.

Towards the Smart Solar Buildings and Communities of the Future in Canada

Andreas K. Athienitis, Centre for Zero Energy Building Studies, University of Concordia, Montreal, Canada
Email: andreask.athienitis@concordia.ca

Keywords: Smart, Solar, Building, Energy

Net-zero energy buildings (NZEBs) are usually described as those that produce from on-site renewable energy sources as much energy as they consume in an average year. This presentation will focus first on modeling and design of such advanced solar buildings to capture solar energy through building-integrated solar systems for simultaneous production of electricity and useful heat, optimally designed windows for capturing passive solar heat gains and daylight and efficient techniques of building-integrated storage. Results from Canadian high performance demonstration buildings under two Canadian research networks are presented with emphasis on modeling and design. Current work by the presenter on development of building-integrated solar systems and predictive control strategies for NZEBs is overviewed with application to a net-zero energy institutional building.

The term “Smart NZEB” is used to describe two major expected characteristics of such buildings:

1. A building that optimally controls its indoor environment and is responsive to occupant needs so as to provide good indoor comfort for work, leisure activities and rest.
2. A building that optimizes its operation so as to substantially reduce energy consumption costs while optimally interacting with energy grids – both electrical and thermal.

Smart NZEBs interacting in an optimal way with smart electricity grids can shift and reduce peak demand for electricity by optimizing production, storage and utilization of energy from renewable energy sources. Smart buildings can become net energy producers over a year through efficient integration of energy efficiency measures such as optimal insulation levels and advanced windows with renewable energy systems such as building-integrated photovoltaic systems. However the routine design of such buildings poses major challenges and requires significant innovations on how we design, construct and operate the buildings – some of these innovations will be briefly discussed. Finally, design concepts for smart solar communities are discussed, including considerations of local transportation and enhanced quality of life.

Renewable Energy Systems: Current Status and Prospects

Soteris A. Kalogirou, Department of Mechanical Engineering and Materials Sciences and Engineering, Cyprus University of Technology, Limassol, Cyprus
Email: Soteris.kalogirou@cut.ac.cy

Keywords: Renewable Energy Systems, Current Status, Solar Thermal, Photovoltaics, Wind Energy, Hydro Systems, Biomass

The purpose of this paper is to present the worldwide status of the various renewable energy systems (RES). This is presented in terms of the total installed capacity of the various types of RES by the end of 2015 and is based on the reports of various international agencies and organisations. The paper initially examines the effects on climate that the use of human activities have and a review of the status of the existing conventional fossil fuels and their expected depletion based on the existing resources and the current rates of consumption. The types of RES examined include the main and most important, in terms of capacity, i.e., solar thermal, solar photovoltaics, hydro systems, wind energy systems and biomass, biogas and biodiesel. Other forms of renewables like ocean energy systems, geothermal and hydrogen and fuel cells are just mentioned. In each type of RES examined in addition to the total installed capacity the status of the technology is given as well as the outlook in terms of prospects and the current research areas. In can be concluded that although the total installed capacity of RES is small, relatively to the total conventional annual fuel consumption, this constitutes an important environmental friendly solution to protest the planet with very good prospects of expansion in the coming years.

Life Cycle Assessment: Low Energy and Low Carbon Modular Housing in Canada

Chinyere Dara, Faculty of Environmental Design University of Calgary, Calgary, Canada
Email: chinyere.dara1@ucalgary.ca
Caroline Hachem-Vermette, Faculty of Environmental Design University of Calgary, Calgary, Canada

Keywords: Life Cycle Impact Assessment, Life Cycle Costing, Shipping Container, Modular Housing, Energy Efficiency

Interest in container-based housing is growing, and there is a possibility to advance its practice in Canada, and elsewhere given its affordability, availability, and other sustainability benefits. This study presents results of an integrated life cycle approach to building performance analysis by comparing the container-based modular units to conventional lightwood frame housing for the three most vital indicators: energy, greenhouse gas (GHG) emissions and cost. The research methods combined: i) envelope design and modelling, ii) parametric optimization and energy simulation using EnergyPlus, iii) life cycle environmental assessment of energy consumption and GHG emissions, using Athena Impact Estimator, and iv) life cycle cost analysis, to support the design of affordable, low energy and low carbon modular housing. This study considered all life cycle phases – from cradle to grave – and is evaluated for the cold climate regions using Alberta, Canada as the study location. The findings reveal the implications of building performance analysis at the early design stage in advancing modular design innovations. The results proved that envelope design strategies and decisions could significantly lower energy use, associated environmental impacts and cost of modular systems, if systematically applied during the modular design stage and before the actual off-site modular production and construction. The pre-production integrated life cycle analysis proved that modular systems being systematically developed will provide higher performing buildings with longer service years compared to common practice design approach.

Simulation of Random Soil Properties with the Local Average Subdivision Method (L.A.S.)

Nikolaos Alamanis, Lecturer, Department of Infrastructure Engineering of Larissa, TEI of Thessaly, Greece
Email: alam@teilar.gr
Panos Dakoulas, Professor, Department of Civil Engineering, University of Thessaly, Greece

Keywords: Simulation, Stochastic Methods, Spatial Variability, Random Fields, LAS Algorithm, Correlation Coefficients, Autocorrelation Lengths

Geotechnical design is one of the objects of civil engineering that involves great uncertainty due to the natural heterogeneity of geomaterials (Kavadas et al., 2010). The parameters of shear strength, stiffness, density, etc., may vary from point to point even in the same soil layer as a result of the natural formation process. Therefore, there is a need to use stochastic methods in the safety evaluation of geotechnical systems, as for example in the stability and seismic analysis of slopes. Stochastic methods have been introduced to calculate the uncertainty and spatial variability of soil parameters. Recent research took into account the spatial variation of parameters using the Random Field Theory. Apart from their cross-correlation, random variables exhibit autocorrelation, a trend in which the soil properties of a point appear to be correlated with the properties of neighbouring soil points (Vanmarcke, 1977). Among the various random field algorithms, one particularly effective is the Local Average Subdivision (LAS) method by Fenton and Vanmarcke (1990). Moreover, such methods are consistent with the concept of risk parameters of soil vibration and constitute their extension as damage indicators, being directly related to the seismic performance of geotechnical systems.

Risk Index in Economic Generation Operation in Power Systems with Renewable Sources

Ebrahim Shayesteh, School of Electrical Engineering and Computer Science, KTH Royal Institute of Technology, Stockholm, Sweden
Email: esh@kth.se

Keywords: Reliability and Risk Analyses, Power System Monitoring and Maintenance, Unit Commitment and Economic dispatch, Renewable Energy Sources

In this paper, we present an index called reliability risk index to help system operator in making decisions and operation based on several parameters considering health, aging, reliability, maintenance, availability and risk of generators including renewable power sources.
This approach not only improves reliability and decreases the risk of the failure of the grid, but also bases the decision on economical aspect which in turn results in the least operational costs for the system considering the minimum required risk level. Another feature of our approach is the assistance in proposing preventive maintenance schedules for each of the players in the system. The idea of this technique originates from the transition from conventional electric power system to smart grid. This transition utilizes new level of monitoring which has been the starting point and integration among different components. The approach is demonstrated through IEEE-RTS test system and the results show that this approach can have great impacts on all agents by increasing not only the availability, but also reducing the risk and costs. The model has been programmed in GAMS software and solved with CPLEX solver.

Material Demand in Global Energy Scenarios, Distribution of Stocks and the Role of Recycling: The Case of Neodymium, Dysprosium, Lithium and Cobalt

Tobias Junne, German Aerospace Center, Institute of Engineering Thermodynamics, Department Systems Analysis & Technology Assessment, Stuttgart, Germany
Email: Tobias.Junne@dlr.de
Niklas Wulff, Technische Universität Darmstadt, Department of Material Flow Management and Resource Economy, Darmstadt, Germany
Tobias Dr. Naegler, German Aerospace Center, Institute of Engineering Thermodynamics, Department Systems Analysis & Technology Assessment, Stuttgart, Germany

Keywords: Material Demand, Energy Transformation Scenarios, Energy System Modelling

Meeting the climate protection targets of the Paris agreement requires a fundamental transformation of the global energy system. However, low-carbon energy technologies often require larger amounts of critical minerals which may impede the transition to a low-carbon economy. We assess the requirements of neodymium (Nd), dysprosium (Dy), lithium (Li) and cobalt (Co) until 2050 under recent, high impact global deep decarbonization energy scenarios. As critical elements are rarely used in heat generation technologies, we focus on power generation and storage as well as transport technologies. The analysis encompasses the identification of bottlenecks taking into account global resources, reserves and annual production quantities. Furthermore, the impact of material recycling on the potential delay in exceeding reserves is estimated. Finally, we assess the regional distribution of in stocks by 2050 to draw conclusions about changes in supply risks due to effective recycling of critical elements. Our study reveals that the metal demands for Nd, Dy, Li and Co may rise dramatically until 2050, mainly driven by electric vehicles. In case the current trend towards ever larger, gearless wind turbines continues, wind power stations are another large consumer of Nd and Dy, while Li and Co demand by stationary battery storage systems only plays a minor role in total Li and Co consumption. High recycling rates do not delay the depletion of reserves, but may result in a sharp decline in demand for primary materials from 2030.
Although the currently known reserves of Dy, as well as the resources of Li and Co are exceeded in some scenarios, it is not expected that potential material bottlenecks will be the reason for a failure to meet climate targets, as generally alternative materials or technologies – albeit with higher costs and / or lower efficiency – are available to substitute the "critical" technologies. However, it is crucial to include the costs of substituting technologies and recycling processes in future scenario development which may be pivotal for the structure of model-based generation portfolios and resulting political support efforts.

Coordination in Decentralized Logistics Systems through a Multi-Period Game-Theory Model

Dimitris Zissis, Department of Management Science and Technology, Athens University of Economics and Business, Athens, Greece
Email: dzisis@aueb.gr
George Ioannou, Department of Management Science and Technology, Athens University of Economics and Business, Athens, Greece

Keywords: Logistics Systems, Multi-Period, Transportation

We consider a decentralized model with a third party logistics (3PL) provider that subcontracts transportation activities to a haulage company. The 3PL provider and the haulage company make their decisions in order to maximize their own profits (rational decision makers), without thinking the global optimum. The decisions are about the levels of investments and the prices. Contracts have long been considered an important tool to achieve node coordination. However, contracts bind the nodes and often are violated or non-fully respected in practice due to dynamic realities or changing conditions of the market. In this work, we propose a two-period game to coordinate the companies and raise the profits for both parties, without signing any contracts between them. We derive analytical expressions of the optimal investments levels, service prices and expected profits under specific assumptions of demand and cost functions. Moreover, we prove that our proposed model; i.e. the two-stage game, achieve to coordinate players' decisions. Numerical examples and sensitivity analysis illustrate the applicability of our proposed approach to real-life logistics systems.

Clean Coal Technologies Based on Calcium Looping Combustion

Dawid Hanak, Power Engineering Centre, School of Water, Energy, and Environment, Cranfield University, Cranfield, UK
Email: d.p.hanak@cranfield.ac.uk
Sebastian Michalski, Power Engineering Centre, School of Water, Energy, and Environment, Cranfield University, Cranfield, UK
Email: S.S.Michalski@cranfield.ac.uk
Vasilije Manovic, Power Engineering Centre, School of Water, Energy, and Environment, Cranfield University, Cranfield, UK

Keywords: Coal, Climate Change, Emissions

To reduce the risks and impacts of climate change, the global mean temperature increase needs to be held well below 2°C and efforts to limit it to 1.5°C above the pre-industrial levels need to be pursued. As there are no other technologies that could significantly reduce emissions from conventional power generation from fossil fuel, carbon capture and storage (CCS) is seen as crucial to decarbonizing the power sector. Calcium looping is regarded as a promising CO2 capture technology that can reduce the electric efficiency penalties to 5-8% points. Due to high-temperature operation, this process can act as a standalone heat source. Therefore, calcium looping combustion (CaLC) can be seen as an emerging class of technologies for thermochemical conversion of coal, especially in conjunction with high-efficiency power cycles. Importantly, the main source of the parasitic load in state-of-the-art calcium looping is a power requirement to drive compressors in both the CO2 compression unit (CCU) and air separation unit. Therefore, the parasitic load associated with calcium looping can be primarily reduced via utilizing alternative options to provide heat for sorbent regeneration, such as an indirect heat transfer from an external heat source. CaLC comprises a combustor, as a primary source of heat for indirect heating in a calciner, and a carbonator where CO2 is separated from flue gas leaving the combustor. This study revealed that the techno-economic performance of the coal-fired power plant based on CaLC was comparable to a conventional coal-fired power plant. Net efficiency of such concept was lower by 2.4%HHV points compared to the conventional coal-fired power plant. Additionally, the cost of CO2 avoided for CaLC was estimated to be 33.9 €/tCO2. The techno-economic feasibility of the CaLC can be improved by employing advanced power cycles, such as supercritical CO2 cycle or helium cycle.

Estimating the Cost of Developing a Chain of Charging Stations for Electric Vehicles on a Highway

Alexander Belenky, Department of Mathematics, Faculty of Economic Sciences, National Research University Higher School of Economics, Moscow, Russia, and Institute for Data, Systems, and Society, Massachusetts Institute of Technology, Cambridge, MA, USA
Email: abelenky@hse.ru
Alain Kornhauser, Department of Operations Research and Financial Engineering, Princeton University, Princeton, New Jersey, USA
Email: alaink@princeton.edu

Keywords: Bilinear Functions of Vector Arguments, Charging Stations, Electric Vehicles, Highways, Linear Programming Problems, Mixed Programming Problems

A tool for determining the structure of a system for supplying electricity to a chain of charging stations for electric vehicles on a highway crossing a geographic region is proposed. The use of the tool allows one to estimate the cost of developing the chain proceeding from a) the expected hourly demand for electricity at every station from the chain, b) existing regulations to be met by the structure of the functioning chain, c) the expected cost of electricity to be supplied to the chain by regional electrical grids, and d) the cost of the equipment to be installed at each charging station to provide electric vehicle drivers with electricity on the highway. The cost estimation problem is formulated as a nonlinear mixed programming one of maximizing the minimum function of a sum of several linear and two bilinear functions of vector variables. It is proven that under certain natural and verifiable assumptions, finding solutions to this problem turns out to be reducible to solving either a mixed programming problem with linear constraints or a linear programming problem and an integer programming one. For a set of model data, an illustrative example of formulating and solving the problem of finding an optimal structure of the chain of charging stations for electric vehicles on a highway is provided, and the ways to use this tool in negotiations with potential investors in the project are discussed.

LED Lighting Systems and Energy Savings

Alison White, SMP Lighting Division of SMP Engineering, Calgary, Canada
Email: awhite@smpeng.com

Keywords: Energy, LED, Savings

Energy savings has been the primary focus for artificial light source used for over 30 years. However, since LED technology was introduced it has become the primary light source. A LED lighting system, is no longer just a light source and/or a luminaire, it must include controls. LED technology was adopted because it promoted energy efficiency. At the time this was true, however there was a trade-off for quality of light. As technology developed and lumens per watt were increasing in efficacy, the quality improved as well. Energy efficient light sources not only save initial energy, but when controlled, it increases the energy savings substantially. This presentation will provide an overview of how technology and efficiency transformed into what we see and use today. In new construction, good design practice typically exceeds energy codes outlined by the authority having judication over the project location. Therefore, we will be focusing on retrofit and/or renovation. There are many case studies published for office space where the space is regularly timed occupancy therefore the two case studies we chose were primarily 24-hour operation. The case studies outline a step by step process, proposed energy savings and summary of results. The first study is a retrofit for a sports center, which was able to reduce both its lighting load and maintenance. The second case study is a report for a propose savings for a senior's residence. Both reports have been completed within the last 12 months and have already reported favourable results. Since quality of light is in most cases an intangible value and harder to quantify, we consider testimonials from the user groups as reliable resources. Finally, an overview of some control technologies used to increase energy savings in the market today but may not necessarily be mainstream, is presented.

Feasibility Study of Smart Fuel Switching System with Residential MicroCHP in Cold Climate

King Tung, Department of Mechanical Engineering, School of Engineering, Ryerson University, Toronto, Canada
Email: kytung@ryerson.ca
Danilo Yu, Department of Mechanical Engineering, School of Engineering, Ryerson University, Toronto, Canada
Alan Fung, Department of Mechanical Engineering, School of Engineering, Ryerson University, Toronto, Canada

Keywords: Simulation, Sustainability, NZEH, Smart Dual Fuel Switching System, Decision Making

Natural gas heating costs in Canada are significantly less expensive than electricity. Many populated areas in Canada have well-established natural gas pipelines, which makes it a popular energy source for heating residential homes. A study was performed to the analyze potential economic, energy, and environmental benefits of a micro combined heat and power (MicroCHP). This system is capable of simultaneously providing power and heating using natural gas as the single energy source. The MicroCHP system consists of a smart dual fuel switching system that uses measurements of environmental conditions to optimize the switching point between the MicroCHP and an auxiliary heating system, minimizing the total energy cost. This system reduces greenhouse gas emissions compared to conventional natural gas furnaces. In this study, numerical models were created to simulate behaviour of the MicroCHP with different types of hybrid systems: a MicroCHP with an auxiliary electric resistance heater, and a MicroCHP with an auxiliary air-source heat pump. The numerical models and algorithms were implemented on a cloud server for over-the-air commands and updates. This system uses the house thermal behaviour data from smart thermostats to estimate the optimal switching point. The research motivation for this study is to reduce energy cost and also provide a flexible load for the electrical grid during peak electricity production periods. This type of technology will reduce greenhouse gas emissions from natural gas heating systems. The system is currently under testing at the Toronto and Region Conservation Authority (TRCA) Archetype Sustainable House located in Vaughan, Ontario, to verify the simulation results.

Laundry Process Improvements towards Energy and Water Savings in Military Camps

Vítězslav Máša, Department of Process Engineering, Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic
Email: masa@fme.vutbr.cz
Michal Touš, Department of Process Engineering, Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic
Email: Michal.Tous@vut.cz

Keywords: Laundry, Water Savings, Energy Savings, Waste Heat Recovery, Military Camp

Laundry containers equipped with washers and dryers and self-service mode are usually applied in military camps. The process itself is quite water and electricity demanding. Furthermore self-service mode does not provide an efficient way of linen handling. Therefore, saving measures may provide significant improvements. In this study, we evaluated electricity and water consumptions in military camps and proposed saving measures. These measures includes served laundry, water recycling and water heating and drying using waste heat from a diesel engine exhaust. These measures may provide more than 50 % reduction in water consumption, nearly 75 % reduction in electricity consumption in washing process and electricity consumption in drying process may be completely eliminated. The payback period of such measures is less than one year.

Waste Heat Recovery from Diesel Engines in Military Camps

Michal Touš, Institute of Process Engineering, Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic
Email: Michal.Tous@vut.cz
Vítězslav Máša, Institute of Process Engineering, Faculty of Mechanical Engineering, Brno University of Technology, Brno, Czech Republic
Email: masa@fme.vutbr.cz

Keywords: Waste Heat Recovery, Diesel Generator, Military Camp

Diesel engines are usually used in military camps to provide electricity for lighting, hot water, air conditioning, etc. There is unused waste heat in exhaust gas which have good potential to be recovered. Hot water preparation seems to be the best application. It can be easily accumulated in a tank for any time use. The water from the tank can cover peak loads during morning and evening hours, i.e. in times of personal hygiene, and can be charged in the meantime because diesel engines run more or less all day long. In this contribution, we analyzed electricity and hot water consumption in a camp, proposed recovery of heat from exhaust gas and evaluated its benefits. It can save significant amount of fuel which is very desirable due to expensive supplies. Simulations showed that up to 25 % of the fuel can be saved. The investment has payback period shorter than one year and saves not only money but also primary energy sources and the environment.

The Value of Modular Design and Project Scale for Alternative Green Investment

Michail Chronopoulos, School of Computing Engineering and Mathematics, University of Brighton, Brighton, UK
Email: m.chronopoulos@brighton.ac.uk

Keywords: Investment, Cost-effectiveness, Modular Design

A modular design enables flexibility, yet typically entails an investment cost premium that may render it more costly than a single large (lumpy) investment. However, with discretion over project scale, a firm can offset this extra cost by building a bigger project. We analyse how this trade-off is affected by different demand structures within the context of investment in modular capacity expansion of nuclear reactors. Small modular reactors reflect a key part of the development of safe, clean and affordable nuclear power, yet have raised questions regarding cost-effectiveness and society's willingness to pay for the commercialisation of a yet unproven technology. By developing an analytical real options model for lumpy and modular capacity expansion, we show how the relative value of these two strategies depends not only on different demand structures, but also on demand and technological uncertainty. Thus, we develop a decision-support process for evaluating each capacity expansion option and determining the dominant strategy, taking into account discretion over timing and project scale. In turn, we derive complementary insights to the well-established energy systems models on the behavioural impact of interacting uncertainties upon the timing of mitigation options. Indeed, contrary to earlier literature that emphasizes the value of flexibility under increasing economic uncertainty, we show that a modular investment approach is not always preferable and that a lumpy investment strategy may dominate depending on demand, technological uncertainty and the responsiveness of the capacity demanded to price. These results are crucial within the context of the risky structural transformation of the electricity sector, which relies heavily on the timely adoption and efficient management of emerging technologies, since failing to understand properly how uncertainty, irreversibility and flexibility interact may result in cycles of under- or over-investment and increase the regulatory risk of corrective policy actions.

Changing the Climate for Change

Marc Vermette, AECOM, Canada
Email: marcvermette998@gmail.com

Keywords: Climate, Change, Construction

The implementation of technological innovation through technology transfer into a market-based operational context is a complex multi-disciplinary and cross-sectoral process that takes time – often 15 to 30 years. In the case of the built environment and building technology, while researchers, engineers, architects, and trade specialists focus on developing new technologies, and construction practices, such is not necessarily the same focus of the construction and commercial real estate industries. In what initially may seem to be counter-intuitive, adoption of new ideas and practices to address recognized public policy concerns like climate change, related clean energy transition, and GHG emission reduction are rarely adopted quickly. It is baffling that conventional systems restrain opportunities for better construction methods and forward-looking planning to taking place. It is in our collective best interests to wonder why it takes so long to adopt new technologies and change building and energy practices. While change is required in the face of climate change and sustainable development goals, there is limited research into this phenomenon. What does exist suggests that the primary roadblocks to change are frequently institutional and regulatory. This problem of 'path dependency' involves a number of factors such as ineffective communication, a lack of risk management, and bureaucratic regulatory and administrative frameworks supporting the status quo. In other words, and relatively speaking, design innovation is easy, but regulatory innovation is hard! Based on my international project experience as a lawyer and an engineer, my presentation will provide some selected case examples of avoidable mistakes as well as case examples of what can work in succeeding to get new sustainable building and construction technologies into practice. Take away information will be methodologies and protocols to introduce and accelerate changes in selected construction contexts.

Seasonal Solar Thermal Energy Sand-bed Storage in a Region with Extended Freezing Periods

Getu Hailu, Department of Mechanical Engineering, Department of Mechanical Engineering, University of Alaska Anchorage, Anchorage, USA
Email: ghailu@alaska.edu
Philip Hayes, Department of Mechanical Engineering, Department of Mechanical Engineering, University of Alaska Anchorage, Anchorage, USA
Mark Masetller, Bristol Bay Campus, University of Alaska Fairbanks, Dillingham, USA

Keywords: Thermal Storage, Sand-bed, Cold Region, Renewable Energy

We present experimental and numerical study of sand-bed thermal energy storage conducted in a region with extended freezing period, which was carried out on a home situated in Palmer, Alaska, 61.6° N, and 149.1° W. Data were collected January 28th 2017 through May 7th 2017. The measured average temperature was 8.1°C compared to the simulated average temperature of 8.6°C. The measured maximum and minimum temperatures were 21°C and -7.8°C while the numerical simulation maximum and minimum temperatures were 17.8°C and -7.5°C. Simulations was also conducted for five years, showing that the system became fully charged by June 14th. The maximum temperature the sand-bed achieved annually was 24.83°C, occurring approximately on July 10th, with a minimum of 11.1°C occurring on January 24th. The results suggest that sand-bed solar thermal storage systems are suitable for climates in regions with long periods of freezing temperatures and can contribute towards net-zero energy status of a residential home.

Flooded Underground Coal Mines in NW Spain: Geothermal Energy Source

Javier Menéndez, Department of Mining and Exploration, School of Mines, University of Oviedo, Oviedo, Spain
Email: javiermenendezr@gmail.com
Loredo Jorge, Department of Mining and Exploration, School of Mines, University of Oviedo, Oviedo, Spain
Email: jloredo@uniovi.es

Keywords: Mine Water, Coal Mining, Geothermal Resources, Renewable Energy

The contribution of renewable energies to the world's total energy demand has increased particularly during the last two decades, and they will continue gaining market share. The Asturian Central Coal Basin (ACCB) is characterized by the presence of predominantly low porosity and permeability materials. Groundwater flow occurs mainly through mining voids, open fractures, and zones of decompression associated with coal mining. Thus, abandoned and flooded mines constitute artificial karst type aquifers. These created underground reservoirs can be economically managed to supply geothermal energy (mainly by means of heat pumps) to villages around the shafts. This potential application of mine water, profitable in both economic and environmental terms, could contribute to improve economic and social conditions of traditional mining areas in gradual decline. Since the 1980s, the idea to reducing the dependency of nuclear and fossil energy sources has risen in Spain. Then, the promotion of renewables is thus in the political interest, and by 2020 it is intended that the country produces 20% of its energy from renewable sources, therefore replacing the energy based on fossil fuels. This paper analyzes the supply of thermal energy for the climatization of a Hospital located at a distance of 2 km from the flooded shaft.

The Water-Energy-Food Nexus in the Circular Economy: Optimisation Options

Nikolaos Voulvoulis, Imperial College London, South Kensington Campus, UK
Email: n.voulvoulis@imperial.ac.uk

Keywords: Optimisation, Economy,WEF

The circular economy is a concept in which growth and prosperity are decoupled from natural resource consumption and ecosystem degradation. By refraining from throwing away used products, components and materials, instead re-routing them into the right value chains, we can create a society with a healthy economy, inspired by and in balance with nature. Taking a closed-loop approach to energy and heat consumption, water and materials, while looking at the Water-Energy-Food (WEF) nexus, the paper explores optimisation options available for collaboration in sectors or production-chains (transport, exchanging utilities such as residual energy, heat, materials, water and space). Looking at the relative values of water, energy and materials, problem structuring in unstructured problems is achieved through policy learning by identifying, confronting, selecting and, wherever possible, integrating divergent viewpoints and knowledge. We raise the need for participatory processes, organised to cross these different boundaries, with particular attention given to collaborative knowledge-sharing and production between all actors involved: scientists, policy makers and stakeholders.

LIFE REGENERATE: Revitalizing Multifunctional Mediterranean Agrosilvopastoral Systems Using Dynamic and Profitable Operational Practices

Priya Devasirvatham, Transfer Consultancy S.L., Barcelona Spain
Sven Kallen, Volterra Ecosystems S.L., Barcelona Spain
Email: Sven@volterra.bio

Keywords: Mediterranean, Silvopastoral, Systems, Regenerative Agriculture

The Quercus-based silvopastoral systems of the Mediterranean basin biome (dehesas, montados and meriagos making up 6 mln ha in the EU) are in rapid decline1. Estimates show that dehesas currently produce a deficit of 200€/ha, land owners face losses of up to 500€/ha due to phytophtora-related diseases, and product prices remain similar to those 30 years ago. Estimations show these agro silvopastoral lands have lost up to 20% of their value and are losing millions of euros in productivity each year2. Agro-subsidies are steadily decreasing. In 2015, farmers in Andalucía reported up to 60% cutbacks in CAP subsidies2. Regional subsidies in this area now cover only 8% of landowners3. In Sardinia, rural abandonment has increased the number of rented/leased farms and the loss of local micro-economies. Anthropogenic and environmental factors challenge the survival of these ecosystems. The younger generation inheriting these systems must transform current production models into cost-efficient operations by lowering input costs, finding alternative sources of income, recycling resources, stimulating natural regeneration, improving soil and increasing farm productivity so that their land can become economically and environmentally sustainable.

LIFE Regenerate's main objective is to demonstrate that these SMEs can become self-sufficient and profitable based on resource efficiency principles and incorporating added value products.

Objectives:

1. Combat loss of natural regeneration and soil degradation in 100 ha of degraded silvopastoral areas by providing effective, mosaic landscape management procedures and improving soil quality;
2. Recover the practice of multi-species rotational grazing
3. Recycle biomass waste on-farm, reducing external input of fodder and creating alternative sources of income;
4. Replicate the project's best practices to 5,000 ha in Spain, Italy & Portugal, proving it as a representative, effective model;
5. Integrate new technologies and monitoring of project advances;
6. Influence policy-making and involve external stakeholders to promote replication and long-term Sustainability.

This project is co-financed by the European Union through the LIFE programme.

EmPOWERment: Addressing Climate Change through Community Solar and Community College Education

Brooke Zanetell, Natural Resources Management Program, University of New Mexico in Taos, United States
Email: zanetell@unm.edu

Keywords: Energy, Solar, Financing, Climate Change, Rural Electric Cooperatives, Community College, STEM, Minorities in STEM; Natural Resources

With an abundance of sun and a deep connection to nature, Taos County, New Mexico, USA, is taking innovative approaches to overcome a history of poverty and energy dependence. The local community college is training the next generation of natural resource managers, and the rural electric co-op is on track to make Taos the first solar-powered county in the nation by 2022.

The rural population of Taos County is comprised of Hispanics, indigenous Natives, and a recent influx of Anglos, with 24% in poverty and a 30% high-school dropout rate. Surrounded by public lands, natural resource management agencies are among the biggest employers in the region. They are on the frontlines of climate change linked to dying trees, mega wildfires, and drought. The supply of skilled graduates does not meet agency demand for new employees. To bridge this gap, the University of New Mexico-Taos created the Northern New Mexico Climate Change Corps (www.ccc.unm.edu) with a U.S. Department of Agriculture grant. The program provides students with: financial stipends, intensive math tutoring, course and career advising, paid internships, and a deep understanding of the causes and solutions to global warming. There is 100% job placement of program graduates and the program is growing in popularity. Additionally, community concerns about climate change and sustainability impelled the local rural electrical co-op to break its contract with Tri-State Coal-Fired Power Plants, which had limited the co-op to 5% of energy being supplied by renewable sources. The co-op is currently committed to providing 100% of its daytime electricity via locally-generated solar by 2022. As rural communities worldwide confront the challenges of climate change, Taos is a model of renewable energy independence and how to train locals to manage and care for their natural resources.

Investigation on Pulverized Coal Char Conversion Behavior Using a Developed Kinetics Model

Jingzhang Liu, Institute of Engineering Thermophysics, Chinese Academy of Sciences, Beijing, China
Email: liujingzhang@iet.cn
Baihang Li, Institute of Engineering Thermophysics, Chinese Academy of Sciences, Beijing, China
Jianguo Zhu, Institute of Engineering Thermophysics, Chinese Academy of Sciences, Beijing, China

Keywords: Char Conversion Rate, Kinetics Model, Gasification Reaction, Oxyfuel Combustion

The coal char combustion with high effective conversion behavior benefits improvement of pulverized coal burnout ratio and flame propagation. Investigation of coal char conversion rate was carried out under enriched-oxygen and high carbon dioxide dilution environments in present work. Combustion characteristics including the char conversion rate, conversion rate ratio, burnout time affected by the limited interaction between char oxidation reaction and char gasification reaction, were investigated under typical environments, i.e., 27%O_2/CO_2, 27%O_2/A_r, 73%CO_2/A_r, 21%O_2/N_2, using experiments and a novel developed kinetics modeling, i.e., the weighted exponential sum model (WESM). Kinetics predictions from present model were also compared with previous typical kinetics models, i.e., the homogeneous reaction model (HRM), the shrinking core model (SCM), the modified volumetric reaction model (MVRM). Results showed that the contribution ratio from gasification reaction, i.e., $C+CO_2 \rightarrow 2CO$, on char maximum conversion rate was 41.1% and 45.2% in 1473K and 1663K, respectively. Meanwhile, the maximum and average interaction contribution ratios decreased about 9.0% and 1.7%, respectively. The maximum rate ratio for oxyfuel combustion increased from 52.7% to 61.7%, and the average ratio slightly increased from 52.5% to 54.2%, respectively. Present kinetics model gave better predictions of the char conversion rate, the maximum conversion rate and burnout time than those predicted by the HRM, SCM and MVRM models, respectively.

International Experiences Ongoing on the Use of Photovoltaics in the Built Environment. Starting Points for New Research Development

Alessandra Scognamiglio, ENEA Centro Ricerche Portici, Energy Technologies Department, Photovoltaics and Smart Networks Division, Photovoltaics and smart grids unit, Portici (NA), Italy
Email: alessandra.scognamiglio@enea.it
Francesco Frontini, Swiss BIPV Competence Center, SUPSI, Campus Trevano, Canobbio, Switzerland

Keywords: Building Integrated Photovoltaics (BIPV), Net Zero Energy Buildings; Integrated Design

The use of photovoltaics (PV) in the built environment (buildings and infrastructures) has been widely investigated in the past 20 years. Research, publications, and projects have advanced knowledge in a significant way. Nevertheless, considering the new demand for renewable technologies fostered by European and national targets, despite so much effort and valuable results, still some issues are challenging for the implementation of PV in the built environment. This is the reason why still new research is needed, in particular when thinking of ambitious energy targets, i.e. related to Net Zero Energy Buildings. For instance, among the open challenges, it is crucial to be able to assess the real potential of the use of PV in urban areas (taking into account limiting factors, such as the urban morphology, as well as building regulations and codes); to predict the real performance in operating conditions, also using simulation models. A crucial role has also have the legal framework (norms, codes and standards) that could have a positive impact for the implementations of PV in building envelopes (i.e. Net Zero Energy Buildings).
The aim of this paper is shaping a cognitive framework, based on the international experiences (including real case studies and operational data), so as to identify new research issues, and to build up new knowledge. It will be based on research that is on-going in two international research networks: the International Energy Agency PVPS Task 15 “Enabling framework for BIPV acceleration”, and the 4 year project COST action PEARL PV (Performance and Reliability of Photovoltaic Systems: Evaluations of Large-Scale Monitoring Data). Regarding this last one, developments within the working group 4 (WG4), “Photovoltaics in the built environment” will be presented.

Enhanced Anaerobic Co-Digestion of Food Waste and Domestic Wastewater by Zinc Supplementation and Intermittent Feed Strategies

Pak Chuen Chan, Department of Civil and Environmental Engineering, Faculty of Science and Technology, University of Macau, Macau SAR, China
Renata Alves de Toledo, Department of Civil and Environmental Engineering, Faculty of Science and Technology, University of Macau, Macau SAR, China
Email: toledora@gmail.com
Hong In Iu, Department of Civil and Environmental Engineering, Faculty of Science and Technology, University of Macau, Macau SAR, China
Hojae Shim, Department of Civil and Environmental Engineering, Faculty of Science and Technology, University of Macau, Macau SAR, China
Email: hjshim@umac.mo

Keywords: Biogas Production, Co-Digestion, Food Waste, Intermittent Feeding, Microelement Supplementation

Food waste is generally poor in micronutrients important for a stable anaerobic digestion performance. This work evaluated the effect of zinc supplementation (as $ZnSO_4$ and $ZnCl_2$) at different concentrations (50, 70, and 100 mg/L Zn^{2+}) to maximize the conversion of organics to methane gas. The intermittent mode (48 h feed and 48 h feedless) was also applied to avoid the reactor failure due to the accumulation of short and long chain fatty acids (SCFAs and LCFAs). The reactor operation was stable and the methane production rate increased from 0.2 to 0.5 L CH_4/L·day with 76±1.2% COD removal efficiency, and the methane content of 61%. Although a stable performance was obtained during the control cycle, the methane yield was low (0.17 L CH_4/g $COD_{removed}$) compared to when zinc was supplemented into the influent at different concentrations (0.28±0.02 L CH_4/g $COD_{removed}$ for 50 mg/L Zn^{2+}, 0.36±0.01 L CH_4/g $COD_{removed}$ for 70 mg/L Zn^{2+}, and 0.37±0.01 L CH_4/g $COD_{removed}$ for 100 mg/L Zn^{2+}), suggesting the zinc supplementation can enhance the conversion of organic matter to methane to some extent. The supplementation of increasing concentrations of Zn^{2+} generally followed a similar trend regardless of the counter ion used (SO_4^{2-} and Cl^-), further confirming the stimulation observed during biogas production was attributable to Zn^{2+} ions. The statistical analysis showed the total SCFAs accumulation, regardless of the zinc supplementation concentration, was significantly different from the control ($p<0.05$) and among different zinc supplementation levels ($p<0.05$). Zinc supplementation was also shown efficient on the LCFAs removal. There are statistically significant differences ($p<0.05$) in the effluent total LCFAs concentration, regardless of the influent supplemented with different zinc concentrations. The disappearance of the unsaturated LCFAs (oleate and linoleate) after the microelement supplementation could be associated to the contribution of both biological and physical (precipitation) removals.

Power-Law and Maximum Entropy Optimization of Large Networks

Roman Belavkin, Department of Computer Science, Faculty of Science and Technology, Middlesex University, London, United Kingdom
Email: R.Belavkin@mdx.ac.uk
Panos Pardalos, Department of Industrial and Systems Engineering, University of Florida, Florida, USA

Keywords: Optimization, Networks, Power Grids

Many large networks, such as the phone calls graph, power grids, the internet domains and routers networks, can be characterized by the power-law degree sequence $N(k)\propto k^{-\beta}$, such that the number $N(k)$ of vertexes (nodes) with degree k is inversely proportional to that degree with the exponent parameter $\beta>0$ (i.e. nodes with higher degree are more rare). It is also known that such graphs can be generated using the preferential attachment procedure, when new nodes are more likely to be attached to nodes with high degree. Here we show that the power-law degree sequence is a solution to the maximum entropy problem with a constraint on the expected logarithm of the degree, and that the preferential attachment procedure is a solution to the dual problem of minimizing Shannon's mutual information between nodes subject to a constraint on the expected path length. This information-theoretic view provides new insights into optimization of large power grids and networks aimed at reducing their costs and increasing robustness.

Co-Modal Emission Calculation and Inventory Methodology

Grammati-Eirini Kastori, Emisia SA, Thessaloniki, Greece
Email: matina.k@emisia.com
Giannis Papadimitriou, Emisia SA, Thessaloniki, Greece
Petros Katsis, Emisia SA, Thessaloniki, Greece
Chariton Kouridis, Emisia SA, Thessaloniki, Greece
Georgios Saharidis, Department of Mechanical Engineering, School of Engineering, University of Thessaly, Volos, Greece

Keywords: Emissions, Road Transport, Bottom-Up Approach, Baseline Scenario

Road transport is an important source of emissions, which derive not only from passenger cars but also from all public transport means. This paper presents a detailed bottom-up approach for calculating emissions from the public transport sector in Greece. An emission inventory methodology was established, which is in line with the general procedure used for calculating emissions from road transport. The innovation of this methodology lies in the fact that detailed actual activity data from everyday life were collected from all transport operators in Greece, instead of using statistical data. The emission factors used for the calculation of emissions were adjusted to match the individual characteristics of the fleet of each transport operator in Greece. The quality of the data was enhanced with a Quality Assurance/Quality Control (QA/QC) procedure that has been followed. The calculated results are compared with results obtained from top-down approaches and with statistical activity data and the comparison showed that the differences between the approaches were acceptable. The methodology and final data can serve as a basis/baseline scenario for future emission inventories.

CERTAINER, advanCed smart E-bike sharing with poRtable ecofriendly auTonomous wireless chArging statIoNs and Emissions monitoRing

Christos S. Ioakimidis, Department of Thermodynamics and Physics Mathematics, 'Net-Zero Energy Efficiency on City Districts, NZED' Unit, Research Institute for Energy, University of Mons, Mons, Belgium
Email: christos.ioakeimidis@umons.ac.be
Konstantinos N. Genikomsakis, Department of Thermodynamics and Physics Mathematics, 'Net-Zero Energy Efficiency on City Districts, NZED' Unit, Research Institute for Energy, University of Mons, Mons, Belgium
Konstantinos Gotsis, Intellig P.C., Athens, Greece

Keywords: E-bike, Emissions, Eco-mobility

This work envisages the development and implementation of the next generation of integrated e-bike sharing systems (eco-mobility), based on portable autonomous charging/docking stations equipped with wireless charging infrastructure and further enhanced with urban emissions monitoring capabilities (showed extensively here), using e-bikes as mobile agents to collect context-aware information in order to improve the e-bike experience of the users. The proposed concept employs existing technologies related to eco-construction with second-hand shipping containers (scalable according to the users' needs) and cloud computing (in the context of Internet of Things) for data processing and coordination of the whole system. Importantly, this work 'promises' a novel solution to improve the security of e-bikes against thefts and vandalism (smart infrastructure). Hence, it is particularly suitable for contemporary cities and touristic places, enabling the fast development and commercial take-up towards the deployment of sustainable and innovative solutions to tackle with societal and environmental challenges, while adding value to the regional as well as to the global European market.

Innovation Based Projection of Energy Future

Eunika Mercier-Laurent, University of Reims Champagne Ardennes, Reims, France
Email: eunika@innovation3d.fr
Gülgün Kayakutlu, Istanbul Technical University Energy Institute Maslak, Istanbul, Turkey

Keywords: Knowledge Based Innovation Management, Energy Future, Innovation Impacts, Cognitive Intelligence

Energy Future is based on a new paradigm in Eco-Innovational approaches of the business world. It is observed that the ecological approaches and heavier use of artificial intelligence cause a necessity for considering the past, present and future of the new impacts in an integrated strategy. Those strategies are expected not only economic or political policies, but, also those that will create synergies on well-established infrastructural systems. A new energy market cannot be created without considering the health, education and distribution systems. Moreover, synergies of multiple sectors are reinforced. Information and Communication technologies collaborating with the energy technologies will provide benefits of a variety of innovation impacts only if the systems can use both machine and human intelligence. Therefore, multidimensional analysis of innovation impacts can be enriched by using the interactions of three generation of human intelligence.
This article aims to define a new vision for analysing the energy future. Knowledge based forecasting and performance analysis examples are shown as a support for decision makers. A conceptual model will be given with a cognitive analysis that leads for a novel mathematical description. The proposed model for the energy future based on the innovation impacts complemented with the time, synergy and system approaches will be a pioneer for both scientists and energy investors.

Turkish Day Ahead Market Electricity Clearing Price Forecasting Using Artificial Neural Network

Aslıhan Dalgın, Gamma Energy, Istanbul, Turkey
Email: adalgin@gamaenergy.com
Francis Rousseaux, University of Reims, Reims, France
Email: francis.rousseaux@univ-reims.fr

Keywords: Electricity, Forecasting, Neural, Network

Power markets cause complexities since power cannot yet be stored in considerable quantities yet. Thus, bringing supply together with the needed demand in a grid environment is the main request of the market players. The main expectation from the deregulation is to enable the generation activities more effective and minimize electricity costs. With the less regulated energy market structure, the market becomes more competitive. In a day-ahead market, participants submit their bids for selling and buying power for the next 24 hours and market is cleared at the prices where the balance is provided for every single hour ahead for 24 hours. Hence the forecasting becomes the critical tool for the market participants. The better the forecasts of day-ahead prices are, the stronger are the bidding strategies for the producers aiming to maximize the profits in the spot markets. Trading companies also require price forecasts in different time horizons in order to negotiate and trade bilateral contracts. Risk managers need price forecasts to assess market risks and decide on hedging strategies timely. Investors require long term price forecasts to take feasible decisions of investing in energy sector. Therefore, well-performing forecast configurations for day-ahead electricity prices is a general need. This study is designed with the motivation of generating the most performant ANN model serving for day-ahead electricity price forecasting for the Turkish power market. Non-linearity and high volatility features of the electricity prices make forecasting a very complex task. The performance of an ANN model is extensively based on the selected input set. The main goal of selection of the impact factors is to generate the optimum set that will lead for the maximum profit. There are quite a few studies on electricity price forecasting in Turkey. However, this study will be supporting the forecasting people in combining the time series of prices and other local market influencers in a model with the minimum forecast error.

Optimal Bidding Strategies for the Day-Ahead Power Market Participation of a Wind Power Plant

Avni Ozozen, Borusan- EnBW Energy, Trading & Market Modelling Büyükdere Maslak, Sariyer, Istanbul, Turkey
Email: aozozen@borusan.com.tr
M. Ozgur Kayalica, Faculty of Management, Department of Management Engineering, Istanbul Technical University, Maçka, Istanbul, Turkey
Email: kayalica@itu.edu.tr

Keywords: Strategies, Power, Market, Optimisation

Optimal bidding strategies for the day-ahead power market participation are mainly discussed in the literature from the perspective of a conventional power plant due to flexibility in generation and higher precision in delivering the promised capacity. Being price taker, due to the existing capacity share in the Turkish Power Market, and having uncertainty in generation, wind power plants are mainly disregarded for studying optimal bidding strategies. Thus, the most prominent efforts have been made in generation forecasting improvement. However, the price risk that comes from balancing and punishment mechanism designs in the market can only be solved to a certain level by forecast improvements and requires market-based solutions. Moreover, the needs for such solutions are becoming more of a vital issue as market encounters negative prices in recent wind project tenders. Assuming a perfect foresight, the maximum revenue of a wind power plant for its sales through day-ahead auctioning would be its actual generation multiplied by the market clearing price determined for the same period. Under the current circumstances, it is clearly known that there is no perfect foresight especially twelve to thirty-six hours prior to delivery. Thus, there will always be deviations from what is sold in day-ahead. These deviations cause extra balancing requirements in the system and punished based on their direction. Shortage in supply means that the generator sold its capacity day-ahead that it will not produce. In respect to this situation, a generator who has shortage is supposed to buy this capacity back from the market with a higher price (as stated in legislations), causing direct costs for the generator. On the other hand, excess in generation means that the generator sold less capacity than it will produce. In such situations, generator sells its positive deviations with a lower price according to the calculations in the legislation, causing opportunity costs for the generator and making sure that it is also punished. Thus, the price of unit power changes from day-ahead to real time generation and balancing according to the net position of the grid. If there is a shortage, then the real-time power is much more expensive and vice versa. Nevertheless, these mechanisms are set to motivate the generator to find solutions to reduce its imbalances and help to have a more stable grid. This paper proposes a model to analyse the impact of wind supplier on the power price by combining the scenario analysis and the optimisation model. The case implementation is for the Turkish day ahead market.

Variability in the UK Grid Carbon Intensity and how It Can Inform Controlled Charging Strategies of Evs

Vasiliki Papaioannou, School of Construction Management and Engineering University of Reading, Whiteknights, Reading, UK
Email: v.papaioannou@pgr.reading.ac.uk
Anthony Simpson, School of Construction Management and Engineering University of Reading, Whiteknights, Reading, UK

Keywords: Electric, Vehicles, Carbon, Emissions

With the number of electric vehicles (EVs) on our roads set to grow significantly, carbon savings can be maximized if charging reflects the time varying nature of the power grid carbon intensity. Whilst EVs have been misleadingly termed 'Zero Emissions Vehicles', it is readily recognized that they require electricity to charge, with consequent carbon emissions from power stations. The common practice of using annual average figures for grid carbon intensity can still lead to a significant error in carbon attribution. Modern power systems' operation varies dramatically from hour to hour because of the just in time nature of electricity production and the balancing mechanisms that maintain grid stability. Although carbon emissions have typically varied with the changes that occurred in the grid fuel mix in response to demand, the increased penetration of weather-sensitive renewables is becoming increasingly significant. The combination of intermittent and variable renewables and turning up, down, on or off different types of plants can cause great fluctuations in the carbon emissions of the grid in an extremely short amount of time. Evaluation of grid carbon intensity in half-hourly resolution, typically measured in g CO_2 eq/kWh, aims to reflect these instantaneous carbon emissions. Controlled charging of EVs has already been widely suggested, as unlimited, unmanaged charging can cause great strain to the low-voltage distribution network. However, besides network security reasons, the implementation of managed charging strategies of EVs can also potentially lead to significant carbon savings if it is informed by half-hourly grid intensity figures. Five different charging scenarios considering carbon emissions and wholesale energy trading costs have been examined leading to different carbon savings ranging from 19% to 31% compared with a default scenario where the vehicle charges at 6pm during peak demand.

Actors' Behaviour Analysis in a Decentralised Energy System: The Case of Germany

Ali Tash, Institute of energy economics and rational energy use, University of Stuttgart, Stuttgart, Germany
Email: ali.tash@ier.uni-stuttgart.de
Audrey Dobbins, Institute of energy economics and rational energy use, University of Stuttgart, Stuttgart, Germany
Isela Bailey, Institute of energy economics and rational energy use, University of Stuttgart, Stuttgart, Germany
Ulrich Fahl, Institute of energy economics and rational energy use, University of Stuttgart, Stuttgart, Germany

Keywords: Energy System Modelling, Energy System Optimization, Behaviour, Renewable Energy, Decentralised Energy System

The German energy system is increasingly becoming diverse and decentralised through the variable spatial distribution of energy resources and the variety of actors and technologies. Therefore, ensuring that the ambitious goals of the Energy Transition are met cost-effectively has become exceedingly complex. To address this issue, numerous energy system models have been developed to provide in-depth analysis of the future development of the energy system. However, most models represent actors in a highly aggregated manner and thus fail to incorporate their unique economic, technical and behavioural characteristics, which consequently leads to achieving unrealistic results. This work develops a methodological approach to represent diverse interests of different players in the energy system and simultaneously capture the effects of those diverse interests on the development of the overall energy system. To this end, a fine and explicit disaggregation of different types of energy providers and consumers is applied to represent their decision-making behaviour regarding operation and investments in various technologies, especially the decentralised ones. Given that by application of a fine disaggregation of the actors, the overall model becomes too large to handle, the work is divided into 5 sector models, consisting of energy providers, households, industry, transport providers and other consumers, each of which is developed separately focusing on the characterization and modelling of different actors within each respective sector. The individual sector models are subsequently combined via a coupling mechanism into one integrated model. Finally, parameters such as policy instruments, socio-economic and socio-technological factors are varied to investigate their impacts on actors' behaviour. The results are expected to assist in capturing the effects of the diversity of actors regarding their decision making behaviour towards investments and operation of decentralised technologies, which consequently helps policy makers to better target those actors that can bring about the desired energy transition more cost-efficiently.

Inspection of Marine Renewable Energy Devices

Michael O'Byrne, Dynamical Systems and Risk Laboratory, School of Mechanical and Materials Engineering, University College Dublin, Ireland
Email: michael.obyrne@ucd.ie
Bidisha Ghosh, Department of Civil, Structural and Environmental Engineering, Trinity College Dublin, Ireland
Franck Schoefs, Université Bretagne-Loire, Université de Nantes, Research Institute of Civil Engineering and Mechanics (GeM)/Sea and Littoral Research Institute (IUML), Nantes, France
Vikram Pakrashi, Dynamical Systems and Risk Laboratory, School of Mechanical and Materials Engineering, University College Dublin, Ireland

Keywords: Marine, Renewable, Energy

Marine Renewable Energy (MRE) devices are continuously being installed around the globe, largely driven by concerns over climate change and the desire to have clean energy. These devices must typically operate in harsh and corrosive conditions, and for this reason, they are particularly susceptible to rapid ageing and deterioration. Inspections are therefore crucial to ensure that safety and structural integrity is maintained, and so that MRE devices can reach, or even surpass, their target lifespan. This paper presents an up-to-date description of the current status of underwater inspections for MRE devices, including a detailed assessment of the state-of-art of underwater Non-Destructive Testing (NDT) tools. While the monitoring of MRE devices has historically been based on recurrent visual observations and assessments of structural condition, recent research efforts have centered on developing effective methods and reliable tools for acquiring, managing, integrating and interpreting structural performance data at a minimum cost while reducing the unreliable human element. Such efforts are particularly valued for underwater inspections where data must be conducted in a limited timeframe and the cost of adapting NDT tools for underwater deployment can be exorbitant in many cases. This paper provides an overview of these recent advances and addresses many practical considerations. Special attention is given to the importance of adopting efficient on-site collection practices and how this can help when it comes to integrating inspection data into the decision-making process. To demonstrate this, we show how an image-based NDT system can be used to extract 3D shape information of marine growth colonized underwater components and consequently fed into a Computational Fluid Dynamics (CFD) environment where fluid-structure interaction analysis is carried out. The information gleaned from such an analysis is useful for engineers. This demonstration also illustrates how NDT tools can often be readily exploited to a greater potential.

Assessing of the Impact of Fiscal Incentives to Promote Electric Vehicles Using the Value-Based DEA method

Isabel Clímaco, ISCA - Coimbra Business School, Polytechnic Institute of Coimbra, Quinta Agrícola, Portugal
Email: iclimaco@iscac.pt
Maria do Castelo Gouveia, ISCA - Coimbra Business School, Polytechnic Institute of Coimbra, Quinta Agrícola, Portugal
Email: mgouveia@iscac.pt

Keywords: Data Envelopment Analysis, Multicriteria Decision Analysis, Electric vehicle (EV), Plug-In hybrid electric vehicles (PHEV), Policy Strategy

The electrification of transportation plays an important role to curbing greenhouse gas (GHG) emissions and ensuring a healthier environment for the European population. Electric Vehicles (EVs), particularly full-electric driving vehicles, offer a clean alternative to vehicles with internal combustion engine (ICEs) by helping to reduce air pollution resulting from fuel combustion. The EU is committed to developing a more sustainable economy, i.e. a more resource-efficient, green and competitive low-carbon economy, of which a decarbonised transportation system is an essential component. Financial incentives directed at EV customers and users are essential for reducing the purchase cost and total cost of ownership (TCO) gap between electric and conventional (internal combustion engine) cars. The aim of this study is to asses and evaluate the impact of different fiscal incentives and other complementary measures to encourage the purchase of EV (BEVs and PHEVs) in eight European countries. For the purpose of evaluating the policy strategy of these countries regarding the introduction of PHEVs and BEVs, a Multicriteria Decision Analysis (MCDA) framework is necessary also considering the preferences of decision makers (DMs). Data Envelopment Analysis (DEA) can be used in the spirit of MCA to assess the performance of Decision Making Units (DMUs), in this case the countries under assessment, that operate in a similar technological environment, allowing the consideration of multiple inputs and multiple outputs in global performance evaluation. The methodology proposed to evaluate the policy strategy of those eight countries for the introduction of PHEVs and BEVs is the Value-Based DEA method, which builds on Multi-Attribute Utility Theory (MAUT). In the Value-Based DEA method, the input (minimizing) and output (maximizing) factors are converted into value functions, in the spirit of MCDA, according to preference information provided by DMs.

Energy Capital Tradeoff for Heat Exchanger Network with Variable Stream Data

Chi Wai Hui, Department of Chemical and Biological Engineering, The Hong Kong University of Science and Technology, Hong Kong.
Email: kehui@ust.hk

Keywords: Optimization, Network, Energy

Design and optimization of heat exchanger network is commonly used for decades to demonstrate advanced techniques in process synthesis. Most of the works on this topic require a set of fixed stream data, i.e. supply and target temperatures, flowrates and heat capacities. Very little work so far tackle problems with variable stream data, involving energy-capital tradeoff is even rare, mainly due to the inefficiency of estimating the heat transfer area or so called area target. The latest area targeting methods for problems with variable stream data either require complex iterative algorithms or disjunctive formulations restrict their application in real world problems. In this paper, a novel area targeting method is proposed. Together with the energy targeting method proposed by Hui (2014), simultaneous energy-capital tradeoff for problems with variable stream data becomes possible and affordable.

A Generic Approach for the Synchronization of Public Transport Services

Dimitrios Rizopoulos, Department of Mechanical Engineering, School of Engineering, University of Thessaly, Volos, Greece
Email: dimrizopoulos@gmail.com
Georgios Saharidis, Department of Mechanical Engineering, School of Engineering, University of Thessaly, Volos, Greece

Keywords: Synchronization, General Transit Feed Specification (GTFS), Public Transport

The current paper analyzes the problem of rescheduling and synchronization of public transit services and the minimization of waiting time that occurs for passengers when embarking on journeys through a co-modal public transport network. In the first sections we discuss fundamental concepts of public transport networks, such as co-modality and data specifications, and the trends that have emerged in the last decades. Furthermore, several approaches are proposed that aim to be flexible, robust and applicable to a wide set of available datasets that have been homogenized according to the General Transit Feed Specification (GTFS) or other Specifications. Parameters are used in the approaches in order to define the degree to which we want to change the existing way that the services operate. Several case studies are presented for European public transport networks, in which a reduction of waiting times is obtained.
This research is ongoing with the contribution of the LIFE programme of the European Union - LIFE14 ENV/GR/000611 (GreenYourMove- GYM). GreenYourMove is a European Research Project co-funded by LIFE, the EU financial instrument for the environment. GreenYourMove's main objective is the development and promotion of a co-modal journey application to minimize GHG emission in Europe. GreenYourMove develops a multi-modal transport planner (both routing & ticketing system) considering all kinds of urban public transportation (urban and sub-urban buses, metro, tram, trolley, trains), where the user gets alternative routes combining more than one transport modes if necessary. The routes are the environmentally friendliest ones, since emissions are calculated for different scenarios.

A Structural Model for Green Bonds

Rossella Agliardi, Department of Mathematics, University of Bologna, Bologna, Italy
Email: rossella.agliardi@unibo.it
Elettra Agliardi, Department of Economics, University of Bologna, Bologna, Italy
Email: elettra.agliardi@unibo.it

Keywords: Green Finance, Bond Yield, Green Bond Premium

Green bonds are a key tool to move financial investments towards green and sustainable environmental projects. Their distinguishing feature is that the proceeds are directed to projects with environmental benefits, primarily climate change mitigation and adaptation. The development of process guidelines (e.g. Green Bond Principles) has encouraged the allocation into green deals and the market for green bonds is expanding at an impressive rate. In the last five years the labeled green bond market has increased till USD 106 billion issued in 2017. This figure is expected to increase further in 2018 and a volume of USD 1000 billion is likely to be reached in 2020. The number of issuers is constantly on increase as well and at the end of 2017 it was above 550 issuers with a geographic base of 45 different countries and involving 29 currencies. Empirical analyses have often found evidence of a 'greenium', that is, a new issue discount that makes green bonds funded cheaper than other bonds from the same issuer. This premium to bondholders is counterintuitive: it cannot be explained throughout credit risk enhancement, because the green labeling and certification is not a financial standard and does not imply any direct impact on the credit rating. Despite the increasing interest in these financial tools, to our knowledge, a theoretical explanation of the green bond price and premium is still an open question. The aim of this paper is to provide a mathematical model in the framework of the structural approach. We obtain explicit evaluation formulas that allows to answer the following questions. What are the determinants of the green bond value? Do green bonds enhance the credit quality of the issuer? How can policy makers attract bondholders towards green investments? Are green bonds a cheap tool to fund sustainable investments?

Waste Heat Recovery Potential Assessment in the European Industry

Gregoris Panayiotou, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Limassol, Cyprus
Giuseppe Bianchi, Brunel University London, Institute of Energy Futures, Center for Sustainable Energy Use in Food Chains, Uxbridge, UK
Paul Christodoulides, Faculty of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus
Email: paul.christodoulides@cut.ac.cy
Georgios Florides, Faculty of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus
Savvas Tassou, Brunel University London, Institute of Energy Futures, Center for Sustainable Energy Use in Food Chains, Uxbridge, UK

Keywords: Energy Consumption, Waste Heat Potential, Carnot Potential, Waste Heat Recovery

European primary energy consumptions (in the order of a few GWh/yr) are mostly due to industrial processes that are characterized by a multitude of energy losses. The ones taking place as waste heat streams in the form of exhausts or effluents occur at different temperature levels. Reducing or recovering such energy flows can contribute to a better environmental performance and an overall lower manufacturing cost. In this study the opportunities and the potential for industrial heat recovery in the European Union (EU) are addressed by identifying and quantifying primary energy consumptions in the major industrial sectors and their related waste streams and temperature levels. The waste heat potential and the Carnot potential are estimated using statistical data concerning the energy consumption of the industrial sectors of each EU country together with the factors proposed by Forman and collaborators (2016). To use these factors the individual processes of each industrial sector are classified according to their temperature range as Lower, Medium and High. The study also discusses the challenges that novel heat recovery or heat to power conversion approaches involve. A further and more precise (than the one based on Forman et al.'s factors) assessment of the energy recovery potential can be carried out using a methodology based on the latest statistical energy databases. It turns out that the overall EU thermal energy waste can be quantified to about 1 GWh/yr.

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Ground Heat Exchanger Model Validation through Software Comparison

Lazaros Aresti, Department of Electrical Engineering, Computer Engineering and Informatics, Cyprus University of Technology, Limassol, Cyprus
Georgios Florides, Faculty of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus
Vassilios Messaritis, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Limassol, Cyprus
Email: vassilios.messaritis@cut.ac.cy
Lazaros Lazaris, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Limassol, Cyprus
Paul Christodoulides, Faculty of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus

Keywords: Ground, Heat, Exchanger, Models

Experimental data are obtained for a Borehole Ground Heat Exchanger (GHE) with a single U-tube configuration, at a depth of 160m, with underwater flow. The monitored inlet and outlet temperatures of the circulating fluid (water) are recorded by a Thermal Response Test. Two similar numerical models, one constructed in the Flex PDE and another in the COMSOL Multiphysics environment, are then validated for the experimental regime described above. The time-dependent convection-diffusion equation of heat transfer was used in both models with the same boundary conditions representing the actual parameters of the installed column. The results obtained by both models, in good agreement with the experimental data, are discussed and assessed. Furthermore, the two computational model responses to various design aspects of GHE are studied and inter-compared.

Potential of the Parabolic Trough Collectors Use in the Industry of Cyprus: Current Status and Proposed Scenarios

Panagiotis Ktistis, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Limassol, Cyprus
Email: panayiotis.ktistis@cut.ac.cy
Rafaela Agathokleous, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Limassol, Cyprus
Email: rafaela.agathokleous@cut.ac.cy
Soteris Kalogirou, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Limassol, Cyprus
Email: Soteris.kalogirou@cut.ac.cy

Keywords: Parabolic, PTC, Industry, Thermal Energy, TRNSYS

Cyprus is the worldwide leader country for the use of solar water heating systems per capita, which are of the thermosiphon solar water heating type. In this paper, an investigation of the perspective to start using parabolic trough collectors (PTC) is carried out. The idea to use PTC systems is still new in Cyprus since there are no installations and it is not a well-known technology yet, but it could create a good prospect by starting from the large industries of the island. Although the industrial market of Cyprus is small, the large amount of incident solar radiation throughout the year and the need of the people to reduce their energy needs, makes the idea to adopt PTC collectors for energy production very tempting. Most of the industries use thermal and electrical energy for their various processes, with the biggest consumer to be the non-metallic minerals industry (glass, pottery and building materials) and the second bigger consumer the food industry. The latter requires large amount of thermal energy which could be provided by PTC since the required temperatures are 120°C - 250°C which is very common range of temperatures for such systems. Thus, parabolic trough collector systems could be a sustainable, profitable and dispatchable technology, especially for the Cypriot industries. This study presents an investigation carried out to summarize the current status of the industrial energy needs as well as the systems being used for energy production currently. Accordingly, an examination of the PTC systems is done in order to identify the potential of installation of such a system in a case study from the industrial sector, considering the energy production, the cost of installation and cost of energy savings as well as the CO_2 emissions reduction. Finally, a discussion is made on the potential of the Cypriot industry to use PTC collectors analyzing the pros and cons of such applications.

Efficiency of Geothermal Heat Exchangers and Design Factors in Cyprus

Panayiotis Pouloupatis, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Limassol, Cyprus
Georgios Florides, Faculty of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus
Email: georgios.florides@cut.ac.cy
Vassilios Messaritis, Department of Mechanical Engineering and Materials Science and Engineering, Cyprus University of Technology, Limassol, Cyprus
Paul Christodoulides, Faculty of Engineering and Technology, Cyprus University of Technology, Limassol, Cyprus

Keywords: Geothermal, Heat, Exchangers, Design, Energy

The sizing and positioning of Geothermal Heat Exchangers (GHEs) in Cyprus is examined through the study of affecting factors. In particular, the influence of the temperature, the thermal conductivity, the specific heat and the density of the ground as well as the pipe diameter are tested through the performance of GHEs with the use of the GLD software program in conjunction with test data. We also show that the positioning of the GHEs affects the long-term temperature variation of the ground around the boreholes. Owing to the large number of parameters involved in the design the desired result can be reached in several manners depending on the fixing of parameters. The analysis presented can serve as a useful tool for the design of GHEs. Also, it can generally be concluded that the island of Cyprus is suitable for geothermal heat pump use and applications.

Making Public Schools Energy Efficient: The TEESCHOOLS Project in Emilia-Romagna Region

Maria-Anna Segreto, ENEA: Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Energy Efficiency Technical Unit, Bologna, Italy
Email: mariaanna.segreto@enea.it
Rovena Preka, ENEA: Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Energy Efficiency Technical Unit, Bologna, Italy
Email: rovena.preka@enea.it
Mario Tarantini, ENEA: Italian National Agency for New Technologies, Energy and Sustainable Economic Development, Energy Efficiency Technical Unit, Bologna, Italy
Email: mario.tarantini@enea.it
Giovanni Margareci, Architect – Energy Efficiency and Management Expert
Email: archgm74@gmail.com
Michele Piazzi, University of Bologna - Energy Engineering
Email: michelepiazzi10@gmail.com

Keywords: Energy Efficiency, Schools, Nearly Zero Energy Buildings (Nzeb), Financial Schemes, Public Buildings

The energy efficiency of buildings, both public and private, has been considered a priority of the National Energy Strategy (SEN) in the recent years. The potential savings in terms of costs and CO2 emissions is notable. Looking at the recent estimates, reported in the 2017 Annual Energy Efficiency Report by ENEA (National Agency for Energy Efficiency), it is indicated that the building sector covers about 40% of the final uses of primary energy in the European Union, with 75% of the structures that are still inefficient from an energy point of view. The public buildings specifically, are considered strategic as they can play an important demonstrative role and act as a driving force, encouraging new investments. Within the TEESCHOOLS project, the theme of public buildings has been focused on school buildings. In the preliminary phase of the project the current state of the art from an energy efficiency point of view of school buildings in Emilia-Romagna region was analyzed. The objective of this paper is to analyze the barriers of these buildings and identify the proper improvement options implementing the Nearly Zero Energy Buildings (nZEB) approach and assess a first financial scheme for the public sector. Using the data made available by the Region, it was analyzed what is the gap to be filled with the definition nZEB in terms of technical interventions in the buildings. On this basis, average costs have been defined for pursuing the nZEB adjustments by refurbishing the schools in Emilia-Romagna divided by year of construction. The ultimate goal is to develop, both technologically and financially, a strategy that facilitates the efficiency of the most inefficient public schools using proper and private funds.

Heat Pump Concept With an Integrated Ice Storage and Alternative Refrigerants for Buildings

Florian Kauf, Institute of Product Development, University of Applied Sciences Ravensburg, Weingarten, Germany
Email: florian.kauf@hs-weingarten.de
Michael Müller, Institute of Product Development, University of Applied Sciences Ravensburg, Weingarten, Germany
Christian J. Uhl, Teesside University Middlesbrough, United Kingdom

Keywords: Alternative, Buildings, System, Energy Efficiency

The presentation describes a project that was financed by the German government over a period of 2 years and was carried out in cooperation between the University of Applied Sciences Ravensburg-Weingarten and a medium-sized company. The content and aim of the research project was to develop a modular heating and cooling system based on a refrigerant cycle for buildings up to 12 kW heat demand, which was optimized in terms of energy efficiency and costs. The core of the system is a new and innovative heat pump concept based exclusively on the use of environmentally friendly refrigerants and energy sources. It will be much cheaper than existing products on the market. Refrigerants that damage the climate and ozone in heat pump technology are dispensed with. In addition, the space requirement and acoustic emissions will be reduced compared to existing systems. Optionally, it is possible to create an energetically largely self-sufficient system in combination with energy storage units using solar power produced by a photovoltaic system and an integrated ice-storage. A comparison of potential alternative refrigerants incl. evaluation criteria will be presented as base for the further development. One of the key innovations is the integrated ice storage using phase change material to storage thermal energy in a small volume and within low mass. The geometry of the heat transferring components has been physically modeled (CFD model) with its geometry and design parameters. The physical model will be described and the optimization process that brought us to an impressive result regarding heat transfer performance, package and requirements regarding industrialization. The thermodynamical integration into the refrigerant cycle allowed to reduce package and to increase efficiency. Challenging was the detection of the ice within the storage to prevent it from demolition.

Improvement of Energy-Conversion Systems Using Advanced Exergy- Based Methods

George Tsatsaronis, Institute for Energy Engineering, Technische Universität Berlin, Berlin, Germany
Email: georgios.tsatsaronis@tu-berlin.de
Tatiana Morosuk, Institute for Energy Engineering, Technische Universität Berlin, Berlin, Germany

Keywords: Exergy-Based Methods, Endogenous and Exogenous Inefficiencies and Costs, Avoidable and Unavoidable Inefficiencies and Costs, Iterative Optimization

Exergy-based methods are powerful tools for developing, evaluating, understanding, and improving energy conversion systems. This presentation deals with integrated advanced exergetic, exergoeconomic and exergoenvironmental evaluations. Advanced exergy-based analyses consider (a) the interactions among components of the overall system, and (b) the real potential for improving each important system component.
The main role of an advanced analysis is to provide energy-conversion-system designers and operators with information useful for improving the design and operation of such systems. Splitting the exergy destruction, the capital investment cost and the component-related environmental impact associated with each single component of an energy conversion system into endogenous/exogenous and avoidable/unavoidable parts and using a further splitting of the exogenous exergy destruction improves (a) our understanding of the processes that take place, and (b) the quality of the conclusions for improvement obtained from the analysis. In the presentation the main features and some recent developments in the area of advanced exergy-based methods were presented, and an application of these methods to an air refrigeration machine was briefly discussed.

Exact and Heuristic Bilevel Programming Algorithms for Optimal Price Bidding of Energy Producers in Multi-Period Day-Ahead Electricity Markets

Eftychia Kostarelou, Department of Mechanical Engineering, School of Engineering, University of Thessaly, Volos, Greece
Email: ekostarelou@yahoo.gr
George Kozanidis, Department of Mechanical Engineering, School of Engineering, University of Thessaly, Volos, Greece

Keywords: Bilevel Optimization, Integer Parametric Programming, Electricity Markets, Optimal Bidding Strategies, Valid Inequalities

We consider the problem of devising optimal price-offers (bids) for maximizing the individual profit of an energy producer who participates in a multi-period day-ahead electricity market. The market exhibits non-convexities, due to the discrete nature of the generation units' commitments. The problem is formulated as a mixed integer bilevel programming model, with the energy producer maximizing his individual profit at the upper level, and an independent system operator ensuring satisfaction of the demand for energy at the minimum total bid-cost at the lower level. Given the problem's technical characteristics and the remaining participating producers' bidding offers, the problem aims to identify the optimal bidding offers of the individual producer, so as to maximize his total profit upon clearing of the market. We prove several important theoretical properties for this problem, and we utilize them to develop both heuristic as well as exact solution methodologies for handling it. The most effective of these methodologies turns out to be a heuristic approach, which, utilizing integer parametric programming theory, finds the optimal value of a single price offer given that the remaining ones are kept fixed at their current values. We present computational results demonstrating that this approach provides high quality solutions while exhibiting reasonable computational requirements. We also demonstrate how the underlying theory can be utilized for the generation of valid inequalities to suitable relaxations of the original problem formulation in which the so-called bilevel feasibility of the obtained solution is not guaranteed. Such valid inequalities can be embedded within a cutting-plane solution framework for identifying the exact optimum of the problem.

An Accelerated Benders Decomposition Method Applied on Crude Oil Scheduling

Antonios Fragkogios, Department of Mechanical Engineering, School of Engineering, University of Thessaly, Volos, Greece
Email: fragkogiosantonios@gmail.com
Georgios Saharidis, Department of Mechanical Engineering, School of Engineering, University of Thessaly, Volos, Greece

Keywords: Benders Decomposition, Fluctuation, Upper Bound, Crude Oil Scheduling

Benders Decomposition Algorithm has extended application in Mathematical Programming. However, the algorithm has certain characteristics that slow down its convergence. Such a decelerating characteristic is the fluctuation of the Upper Bound (in a minimization problem), which is dealt with in this study. The fluctuation of the Upper Bound is analyzed, its origin is described and its necessity is discussed. Instead of solving the Primal Subproblem in each iteration, this study focuses on solving the Dual Subproblem. The authors propose a modified Benders Decomposition Algorithm, where the fluctuation of the Upper Bound is significantly reduced by exploiting, in each iteration, information of the Dual Subproblem derived from previous iterations. More specifically, the addition of an extra constraint in the Dual Subproblem leads to a valid Auxiliary Dual Subproblem, which produces better cuts and results in faster convergence of the algorithm. The latter has not been finalized yet and the authors apply a premature version of it on the problem of Crude Oil Scheduling in a refinery. The early computational results are really promising, as they significantly reduce the total iterations needed to reach convergence.

Ownership Unbundling and Monopoly Privileges in Electricity Transmission

Alexander Filatov, Far Eastern Federal University, Vladivostok, Russia
Email: alexander.filatov@gmail.com
Mikhail Vasilyev, Melentiev Energy Systems Institute SB RAS, Irkutsk, Russia
Roman Zaika, Melentiev Energy Systems Institute SB RAS, Irkutsk, Russia

Keywords: Electricity Transmission, Natural Monopoly, Oligopoly, Strategic Interaction, Regulation, Potential Competition, Monopoly Privileges, Ownership Unbundling, Merchant Lines

The paper discusses how ownership unbundling and government-granted monopoly privileges in electricity transmission affect end consumer electricity prices, and social welfare. Four cases are considered: government-granted regulated and unregulated transmission monopolies and a sole incumbent transmission company (without monopolistic rights) under and without ownership unbundling conditions. Aprioristic mathematical modeling taking into account potential and real competition between incumbent transmission company and new possible entrants shows the following:

1. The regulation which gives no monopoly privileges in transmission and allows generating companies to construct and operate their own transmission lines can effectively decrease end consumer prices even at high market entry barriers (high costs of new transmission lines).
2. Ownership unbundling makes the effect of the potential competition in transmission much worse, especially if new lines are expensive to construct. Therefore a reasonable policy would be to stop introduction of ownership unbundling and to give preference instead to other forms of the industry structure.
3. Moreover, the antitrust policy which brings the generation market structure close to the "perfect competition" destroys the ability/motivation of generating companies to invest in merchant transmission and thus prevents potential competition in transmission. This harms end consumers causing an increase in end consumer prices.

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Energy Markets: Optimization of Transmission Networks

Alexander Vasin, Department of Operation Research, Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia
Email: vasin@cs.msu.su
Olesya Grigoryeva, Department of Operation Research, Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia
Nikita Tsyganov, Department of Operation Research, Faculty of Computational Mathematics and Cybernetics, Lomonosov Moscow State University, Moscow, Russia

Keywords: Optimization, Transmission, Networks, Energy

An energy market typically includes its own transmission system. We consider a problem of its optimization and aim to maximize the social welfare with account of production costs, consumers' utilities and costs of transmission capacities increments. The problem turns out to be NP-hard under positive fixed costs of transmission lines expansion. For a market with a tree-type network we propose a method of the supply-demand balances transfer to the root node. The method proceeds from the known Welfare Theorem and provides a solution of the auxiliary problem of convex optimization with zero fixed costs of the lines expansion. Complexity of the method is quadratic with respect to the number of nodes. We modify the method in order to obtain an approximate solution of the original problem. For exact solution, we propose a method based on the concept of the welfare function supermodularity with respect to the set of expanded lines. For chain-type networks we confirm efficiency of the method by results of computational experiments.
The problem of transmission system optimal development till a given planning horizon is also discussed. We provide the formal setting and reduce finding of the optimal plan to the finite set of convex auxiliary problems.

Graphical Models for Transmission Expansion Planning

Ivan Zorin, Center for Energy Systems, Skolkovo Institute of Science and Technology, Moscow, Russia
Email: Ivan.zorin@skoltech.ru
David Pozo, Center for Energy Systems, Skolkovo Institute of Science and Technology, Moscow, Russia

Keywords: Transmission Expansion Planning, Long-Tern Planning, Bayesian Networks, Optimization Under Uncertainties

Transmission Expansion Planning (TEP) is one the crucial problems of energy systems. It concerns to decision-making processes of determining the best line reinforcement of the existing network. The TEP should account for the possible futures foresight of parameters such as demand's growth, level of renewables' penetration or cost of primary energy resources. Although the TEP solution should accommodate to any possible realization of uncertainties, the decision has to be made beforehand. Therefore, TEP problem should thoughtfully recognize all potential uncertainties, via experts knowledge and forecasting tools. However, finding distributions for uncertain parameters is a hard problem too. Our proposed approach to addresses the TEP problem as a combination of graphical models and mathematical optimization techniques. Graphical models are used to infer distributions of interest for solving stochastic TEP problem considering all the uncertainties and correlations between them.

Coordination of Interaction between Various Types of Consumers and Power Supply Company for Demand-side Management

Natalia Aizenberg, Energy Systems Institute Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia
Email: ayzenberg.nata@gmail.com
Nikolai Voropai, Energy Systems Institute Siberian Branch of the Russian Academy of Sciences, Irkutsk, Russia

Keywords: Load-Controlled Consumer, Electric Supply Company, Electricity Consumption Management

Demand-side management in smart grids has emerged as a hot topic for optimizing energy consumption. In conventional research works, energy consumption is optimized from the perspective of either the users or the power company. Our paper is concerned with the game theoretic mechanisms of interaction between a load power company and several types of power consumers (with elastic and inelastic demand). Expanding an analysis of consumers, we focus on bounded rational and fully rational consumers, and define them with respective utility functions. The primary goal of the research is to form optimal electricity rates. The rates will help us avoid an adverse selection situation (where all consumers choose one and the same rate), and construct a separating equilibrium. The objective of our method is to reduce the peak-to-average power ratio by optimizing the users' energy schedules. We use demand-side management (DSM) principles, analyzing the load at different time periods of the day for different types of consumers. In addition, we consider a model where three entities interact: the energy company, distribution network and consumers.
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