PROGRAMME PREVISIONNEL

IFORS 2017 - 21st Conference of the International Federation of Operational Research Societies

17 to 21 July, 2017, in Quebec City, the capital of the province of Quebec, Canada

AREA Energy, Environment, Climate

STREAM Long Term Planning in Energy, Environment and Climate

Nadia MAÏZI

SESSION Power Systems Planning and Uses - Edi ASSOUMOU

Developing systematic innovation principle to resolve the structural paradox of Nuclear-Free Homeland

Yi-Chun Chen, Department of Business Administration, National Central University
Dong Shang Chang, Business Administration, National Central of University
Chun-Cheng Chen, Business Administration, National Central University

After suffering the nuclear disaster of Fukushima in Japan, the energy policies and the safety of nuclear power generation have been revisiting by many countries in the world. In order to efficiently respond this issue, the government in Taiwan addressed new energy policies toward a Nuclear-Free Homeland in 2025, which include exploring renewable energy, improving power generation efficiency, reducing carbon with saving energy and implementing electricity liberalization. However, the initiating energy policies results in the structural paradox of contextual complexity among the economic, environmental and social dimensions. Therefore, this study firstly employs a Theory of Inventive Problem Solving (TRIZ) to develop systematic innovation principle for resolving the structural paradox of the energy policy. Secondly, the systematic innovation principle of Nuclear-Free Homeland will be further evaluated by the Multiple Criteria Decision Making (MCDM) method, which is the Decision Making Trial and Evaluation Laboratory (DEMATEL) for identifying the causal relationship and degree of key influence among the innovation principles. The research result of this study will propose the key decision guidelines for helpfully fulfilling the prospect of nuclear-free homeland in Taiwan.

Keywords: Multi-Criteria Decision Analysis, Decision Theory and Analysis

Optimization Problem for Power Flow Controller

Takayuki Shiina, Department of Industrial and Management Systems Engineering, Waseda University
Jun Imaizumi, Faculty of Business Administration, Toyo University
Chunhui Xu, Management Information Science, Chiba Institute of Technology
Susumu Morito, Industrial and Management Systems Engineering, Waseda University

In power delivery systems, the use of dispersed generation and security control to improve network utilization requires the optimal use of system control devices. The installation of loop controller allows the distribution system to operate in a loop configuration, achieving effective management of voltage and power flow. In the investment planning process, it is important to identify the optimal location and installed capacity of the equipment such that all operational constraints are satisfied. The installation of equipment is formulated as an integer programming problem, but because the calculation of flow is a non-convex nonlinear programming

problem, a solution is difficult to find. This paper presents a method for identifying the optimal location and capacity with the minimum installation cost. Our novel approach uses an economic model that considers the fixed costs. A slope scaling procedure is presented, and its efficiency is demonstrated using numerical experiments.

Keywords: Applications, Energy; Optimization, Industrial; Programming, Mathematical

Energy Vehicle Routing Problem for Differently Sized and Powered Vehicles

Herbert Kopfer, Department of Business Studies & Economics, Chair of Logistics, University of Bremen
Benedikt Vornhusen, Chair of Logistics, University of Bremen

Electric vehicles (EVs) and combustion-powered vehicles (CVs) differ substantially with respect to several characteristic factors that have major impacts on vehicle routing. EVs are more energy efficient than CVs, but they have a smaller driving range, and compared to CVs with the same gross weight, they have a lower payload. In this contribution, various vehicle fleets with differently sized EVs and CVs are considered for vehicle routing. First, EVs are opposed to CVs. Second, the effect of increasing the battery capacity of EVs is investigated. Third, the characteristics of mixed fleets are analyzed. The computational results are generated by solving a MIP formulation of the introduced Energy Vehicle Routing Problem with Time Windows, Recharge Stations and Vehicle Classes (EVRPTW-R-VC) by means of a commercial solver.

Keywords: Transportation; Routing

The long term potential for electricity and gas grids integration in France

Edi Assoumou, Centre de Mathematiques Appliquees, Mines ParisTech
Rémy Doudard, Centre for Applied Mathematics, MINES ParisTech
Jerôme Gutierrez, Center for Applied Mathematics, Mines ParisTech-ARMINES

To respond to the sustainability challenge, future electric systems are expected to be essentially based on low carbon solutions and also to be more flexible in order to balance supply and demand with more variable renewables. Among the options to achieve these goals a higher integration of electricity and natural gas grids could be beneficial. The operational reactivity of gas power plants could help balance the intermittency of solar and wind. Conversely, in a power to gas mode, excess electricity could be stored as hydrogen in the gas grid or even converted to synthetic methane using captured carbon dioxide. In this study we will focus on the condition of such an interaction for the future French power system by 2050. Using a LP framework to model the electricity and gas supply/demand problem, we will discuss investment and operational decisions (at an hourly resolution) for representative days and seasons.

Keywords: Applications, Energy, Applications, Climate Change

SESSION Short- and Long-Term Optimization in Water Networks - Sophie DEMASSEY and Gratien BONVIN

Planning Water Tanks by combining Reduction, Optimization and Simulation

Corinna Hallmann, DS&OR Lab, University Paderborn

In recent years, the optimization of water distribution systems has gained more and more attention. In Germany, this is caused by several reasons. One of those reasons is the decreasing water consumption in the last two decades. When the water distribution systems were built the planners forecasted increasing water consumption and built the components accordingly. But as the consumption decreased there are a lot of components which do not work efficiently. In this work an application is presented that optimizes water tanks. This includes determining the optimal dimension and location of new tanks as well as the optimal dimension of existing tanks. This objective is subject to some constraints such as satisfying the demand of clients at each time step, providing the necessary amount of water for firefighting or fulfilling the nonlinear head loss equations which describe the hydraulic properties of a water distribution system. These equations are nonlinear and non-convex and due to these equations and the presence of binary variables for the tanks, the proposed mathematical optimization model becomes a non-convex MIQCP (Mixed Integer Quadratically Constrained Program). To solve this model for problem instances of realistic size, the presented application does not only contain mathematical optimization techniques but also several network reduction techniques as well as a hydraulic simulation. The combination of these different techniques is discussed in this work

Keywords: Applications, Water Management; Programming, Nonlinear; Optimization, Engineering

Pump scheduling in drinking water distribution systems through convex relaxation and time step duration adjustment

Gratien Bonvin, CMA MINES ParisTech
Sophie Demassey, CMA MINES ParisTech

The pump scheduling problem in drinking water distribution systems aims to minimize the electrical costs due to pumping while ensuring the supply of water to end-consumers. Recently, new interests concerning this problem have been observed because drinking water networks seem well-suited for taking advantage of new electricity markets such as spot markets and secondary electricity grid regulation, because of their water storage ability and the flexibility in the pumping operation. However, the optimal control of a drinking water distribution system remains complex because it relies both on discrete decision such as switching pump on and off, and nonlinear constraints for the description of pressure-related physical laws. By arguing that the non-convex constraints tend to be fulfilled because of the shape of the objective function, even if we donâ€™t take them into account, we propose to approximate the non-convex constraints by their convex hull. Then, a feasible solution is recovered by adjusting the time steps duration. Applications to two networks previously studied and comparison with proposed methods are presented in order to highlight the relevance of our solution.

Keywords: Applications, Water Management; Programming, Nonlinear; Scheduling

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SESSION Models for energy and environmental issues - Olivier BAHN

Assessing butanol from integrated forest biorefinery: A combined techno-economic and life cycle approach

Annie Levasseur, CIRAIG Polytechnique Montréal
Olivier Bahn, GERAD and Decision Sciences, HEC Montréal
Didier Beloin-Saint-Pierre, EMPA

Mariya Marinova, Université Laval
Kathleen Vaillancourt, ESMIA Consultants

The life cycle assessment (LCA) methodology is increasingly used to ensure environmental sustainability of emerging biofuels. However, LCA studies are usually not performed at the process design stage, when it would be more efficient to identify and control environmental aspects. Moreover, the long-term economic profitability of biofuels depends on future energy and climate policies, which are usually not considered in techno-economic feasibility studies. This paper proposes a holistic approach, combining the LCA method and a TIMES energy system model, to offer a simultaneous assessment of potential environmental impacts and market penetration under different energy and climate policy scenarios of emerging energy pathways. The approach is applied to butanol produced from pre-hydrolysate in a Canadian Kraft dissolving pulp mill. Results show that 1) the energy efficiency of the butanol production process is a critical aspect to consider in future design and implementation steps in order to make butanol a competitive fuel among all other alternative fuels, 2) with a 50% internal heat recovery, butanol has a role to play in the transportation sector under climate policy scenarios, and 3) higher supply costs for feedstock might undermine the competitiveness of butanol on the medium term (2030), but probably not on the long-term (2050).

Keywords: Sustainable Development; Applications, Energy; Environmental Management

Cross-Border Pollution and Environmental Quota

Salvador Sandoval, Métodos Cuantitativos, Universidad de Guadalajara

This work develops a CournotÂ´s oligopoly model, of partial equilibrium, under reciprocal dumping restraints between two countries. The domestic companies allocate part of their production to the local consumption and the rest to the export market. Firms generate pollution in their productive processes, but they possess technology to reduce externalities. We use an instrument of environment policy: quota. We suppose that exist croos-border pollution, i.e, the countries involved in the reciprocal dumping export part of their pollutants to another country, and the remaining emissions are assimilated in the producing country. The pollution quantities the companies yield in each country are distributed in direct proportion to the quantities produced of the good for local consumption and the export market. The results are: a) if the marginal cost for polluting is very high, then government sets up the minimal quota, i.e, it doesn't allow emissions from the companies, putting more value on the harmful effects of such emission to the environment over the other components of the well-being function; b) the most inefficient country imposes the major quota of pollution, which implies that government favors the competitiveness of the local companies, allowing them a higher level of pollutants for reducing costs and increasing productivity.

Keywords: Environmental Management; Sustainable Development; Economic Modeling

Exploring deep decarbonization pathways to 2050 for Canada using an optimization energy model framework

Olivier Bahn, GERAD and Decision Sciences, HEC Montréal
Kathleen Vaillancourt, ESMIA Consultants
Erik Frenette, ESMIA Consultants
Oskar Sigvaldason, SCMS Global

The main objective of this paper is to explore deep decarbonization pathways for the Canadian energy sector that would allow Canada to participate in global mitigation efforts to keep global mean surface temperatures from increasing by more than 2Â° Celsius by 2100. Our approach consists in deriving minimum cost solutions for achieving progressive emission reductions up to 2050 using the North American TIMES Energy Model (NATEM), a detailed multi-regional and integrated optimization energy model. With this model, we analyze a baseline and two 60% reduction scenarios of combustion related emissions by 2050 from 1990 levels, with different assumptions regarding projected demands for energy services and availability of technology options for carbon mitigation. The first reduction scenario includes only well-known technologies while the second one considers additional disruptive technologies, which are known but are not fully developed commercially. Results show that three fundamental transformations need to occur simultaneously in order to achieve ambitious GHG emission reduction targets: electrification of end-use sectors, decarbonization of electricity generating supply, and efficiency improvements. In particular, our results show that electricity represents between 52% and 57% of final energy consumption by 2050, electricity generating supply achieves nearly complete decarbonization by 2025 and final energy consumption decreases by 20% relative to the baseline by 2050.

Keywords: Applications, Energy; Decision Support Systems; Optimization, Modeling

Long-term energy modeling for a decarbonized world: an assessment of the Paris Agreement with an optimization bottom-up model

Sandrine Selosse, Centre for Applied Mathematics, MINES ParisTech
Seungwoo Kang, Centre for Applied Mathematics, MINES ParisTech
Nadia Maïzi, Center for Applied mathematics, MINES ParisTech

A historic international climate agreement was adopted by all 195 parties at the UNFCCC on December 2015, to respond to climate issue. The 21st Conference of Parties (COP 21) then marked a decisive stage in the transition to a decarbonized world, with countries calling for a more ambitious long-term goal. Using a long-term prospective approach, and more precisely the bottom-up optimization model TIAM-FR, we investigate different decarbonization pathways of the world energy system to reach the 2Â°C UNFCCC objective on the one hand, and assess the Paris Agreement with the Nationally Determined Contributions (NDCs) on the other hand. Our analysis then focuses on the effects of the Paris Agreement on the level of GHG emissions and the corresponding technological solutions in global and regional perspectives (developed, fast developing or developing countries). While the global contribution of all countries appears essential to reach the ultimate goal of the Paris Accord, a fair level of contribution from developing countries has to be determined; we then discuss the principle of common but differentiated responsibilities. Climate constraints tending toward a 2Â°C objective involving significant decarbonization of the power system with considerable investments in renewable energies as well as in carbon capture and storage technologies, notably with bioenergy, we discuss the role of this option and of the biomass potential.

Keywords: Applications, Energy Optimization, Modeling Sustainable Development

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SESSION Behavioural Economics for Energy and Environmental Challenges - Sandrine SELOSSE and Ankinée KIRAKOZIAN

Bad, for the greater (public) good: Third-party monitoring and sanction on pro-environmental behavior.

Ankinée KIRAKOZIAN, Centre de mathématiques appliquées, MINES PARIS TECH SOPHIA
Agrès FESTRE, GREDEG, University of Nice Sophia Antipolis
Pierre Garrouste, GREDEG, University of Nice Sophia Antipolis
Mira Toumi, GREDEG, University of Nice Sophia Antipolis

It is well recognized that incentives can influence the cooperation of individuals in providing public goods. The aim of this study is to experimentally adapt a Public Good Game (PGG) to the environmental issue of waste management. We report an experiment in which players have to cooperate in order to reduce the cost of waste sorting treatment. Bisides the traditional PGG, a third-party player (Advisor) is introduced in each group in the incentivized treatments. The third party has the possibility to provide a recommendation on the desirable individual contribution (Treatment 1), or collectively punish the non-cooperative behaviors by increasing the tax rate (Treatment 2). Furthermore, participants perform an effort task to increase their given initial endowments, and a measure of social preferences through a Social Value Orientation test (SVO). We find that both the advice and the threat of sanction increase significantly the average level of individual contributions. However, we see that once the sanction is applied, it ha no significant effect in increasing cooperation, but on the contrary decreased it. Moreover, we find in line results on altruism hypothesis that high income individuals contribute more in absolute value compared to low income ones Becker (1974).

Keywords: Behavioural Operational Research; Environmental Management

Nudging electricity consumption within firms. Feedbacks from a field experiment

Christophe Charlier, Economic, Université Côte d'Azur, CNRS, GREDEG
Ankinée KIRAKOZIAN, Centre de mathématiques appliquées, MINES PARIS TECH SOPHIA
Gilles Guerassimoff, Centre for Applied Mathematics, Mines ParisTech
Sandrine Selosse, Centre for Applied Mathematics, MINES ParisTech

Energy consumption is a serious environmental issue due to global warming and pollution. Public policies are developed in this context. Behavioral economics pays particular attention to the use of nudges. A nudge is a form of policy aimed at changing individual behaviors without using financial incentives or order, for example by providing information to individuals so as to conduct behaviors in the direction desired by the policy-maker. Interestingly private nudges can be imagined for companies. Many economists and psychologists have studied the impact of nudges on households proenvironmental behaviors. Yet, studies focusing on nudging employees' energy use are rare. The objective of our paper is precisely to test the effect of 3 nudges on employees' energy consumption with the help of a field experiment. The first nudge alerts individuals on good energy consumption practices. The second one stresses the responsible use of energy regarding environmental stakes. Finally, a social comparison nudge is used informing employees on others' energy consumption in firms participating to the experiment. The field experiment is conducted with 50 French companies' sites. These companies are equipped with Building Management System, allowing obtaining a daily electricity consumption. The experiment is conducted over 12. The data collected are subjected to statistical and econometric processing allowing us determining the impact of the various nudges tested.

Keywords: Behavioural Operational Research; Applications, Energy

Tools for the improvement of households energy management

Gilles Guerassimoff, Centre for Applied Mathematics, Mines ParisTech

Energy consumption in tertiary and residential sector is one of the biggest parts of the total with more than 40%. With the new regulation in building construction we are able to produce buildings producing energy instead of consuming it. However, the appliances level in households is increasing a lot and the level of energy consumption of these objects becomes the major energy consumption of a household. Some experiments have been tested to assess the efficiency of several tools for different actions. On one hand we can inform people of their energy behavior and try to change their habits in a positive way of a reduction of their consumption. To provide such tools, it is important to provide and to collect the right information in order to give a dedicate message in each situation. To fulfill this point it is important to include some sociological consideration in the analyses of the data. Other ongoing experiments try to analyse by several statistical and machine learning techniques a rich survey of an important sample of population to establish some profiles and help the household in their energy consumption reduction. This presentation will introduce the two approaches with some results and way of progress.

Keywords: Applications, Energy; Data Mining; Sustainable Development

Reduce, Reuse or Recycle? Household Decisions over Waste Prevention and Recycling

Paul Missios, Economics, Ryerson University

Households have choices when it comes to reducing waste sent to landfills: reduction of consumption or packaging, reuse of goods purchased, or recycling. We adopt a holistic approach to the analysis of these choices as separate but related facets of households' waste management behaviour. Theoretically, households produce waste as a by-product of their consumption and must then deal with it either by curbside disposal or by recycling. Managing additional waste being costly, households may engage in waste prevention, i.e. produce less waste by reducing their consumption level and/or changing their consumption patterns in favour of less waste-intensive products. As curbside disposal, waste prevention and recycling relate to the same problem and are linked via several constraints, we employ a three-equation mixed process estimation strategy which allows for the error terms of the three equations to be correlated. For the study, we rely on an original data set that permits defining waste prevention comprehensively from a list of 19 waste prevention activities, that provides for a more balanced policy representation (in terms of presence versus absence of unit pricing), and that covers a wide range of attitudinal elements, values, and norms. We also examine individuals' decisions over recyclable items that carry a refundable deposit in terms of both purchasing and returning habits, with particular attention to the interaction between a refundable deposit system and unit pricing

Keywords: Behavioural Operational Research; Environmental Management

SESSION Machine learning for applications - Gilles GUERASSIMOFF

A Comparative Study of Ensemble Classifiers for Credit Scoring

Youqin Pan, Marketing and Decision Science, Salem State University

In this study, we investigate the performance of several ensemble classifiers for consumer credit scoring. Two financial data sets are chosen for the experiments: German Credit and Australian Credit. The findings are encouraging; our results demonstrate that random forest and gradient boosting outperform other ensemble classifiers utilized in this study.

Keywords: Data Science; Data Mining; Machine Learning

A Study on the Eye Movement Behavior Data Collected through An Eye Tracker Using A Self-Organizing Learning Intelligent System

JongChen Chen, Information Management, National YunLin University of Science and Technology

Eye-tracking, a derivation of the technology combining computer graphics and animation, helps us to understand how we use our eyes to differentiate objects. Traditional Chinese characters, which have evolved over thousands of years, were used as the target domain of this study. This is because some of them are different significantly while some slightly, but yet differentiating them seems like no problem at all for those people familiar with Chinese characters. As a result, Chinese character identification seemed to be appropriate testbed for us to investigate how people reacted to slight or similar patterns. In this study, an eye-tracking device developed by Sweden Tobii Technology was used to detect how each individual responded with his (her) eyes to each character, abstracted as a gaze distribution matrix. Twenty subjects were invited and 600 commonly used Chinese characters were chosen. Each individual was asked to differentiate each of these characters in a random manner. Cross correlation analysis of these gaze matrixes for the responses of different people to same character were performed. We also looked into which parts of the characters were comparatively significant that people used to separate different characters and which parts comparatively insignificant that people tended to ignore it.

Keywords: Applications, ComputerScience; Data Mining; Machine Learning

Forecasting short-term electric energy demand in Australia, Brazil and G7 countries through Bagging exponential smoothing methods

Erick de Oliveira, Department of Aerospatial, Energy and National Defence, Brazilian Innovation Agency (Finep)
Fernando Luiz Cyrino Oliveira, Industrial Engineering, Pontifical Catholic University of Rio de Janeiro

Ensuring an adequate supply of energy is a pressing national priority in almost every nation in the world. One kind of time series which is of major interest, from both academic and practical perspectives, is the short-term electric energy consumption. In this connection, this paper expands the fields of application of combined Bootstrap aggregating (Bagging) and exponential smoothing methods to the electric sector in order to obtain more accurate demand forecasts. Different approaches are tested using monthly data from 9 countries (Australia, Brazil and G7 countries) and a comparative out-of-sample analysis is conducted on the basis of several performance metrics. The results show that a combination of a seasonal-trend decomposition, a moving block bootstrap (MBB) aggregation approach and specific exponential smoothing methods can substantially improve the forecast accuracy of the demand for energy end-use services in different countries. In many cases the gains are noteworthy when compared with single forecasts on the real data. For the Australian electricity consumption, for instance, the symmetric Mean Absolute Percentage Error and the Root Mean Squared Error obtained using a MBB Multiplicative Holt-Winters approach were almost 49% and 60% lower

than the ones obtained in a single Multiplicative Holt-Winters forecast on the real data. It is our belief that equally satisfactory results can be reached on other occasions such as different countries and time series.

Keywords: Machine Learning; Simulation; Applications, Energy

Understanding Tank Cleaning Time by Utilizing Geospatial data and Machine Learning Techniques

Burak Cankaya, Industrial Engineering, Lamar University

GPS devices give signals that define their locations and other features with a timeframe. These devices can be found on cellphones, cars, vessels, trains, and planes. When the data for a specific area evaluated it is commonly seen on the map that the vehicle moves between points. In order to understand the movements of vehicles, the vehicle movement patterns should be understood. This research is one of the pioneer studies that labels the vehicle movements with activities and makes it possible to track the activities of moving flocks. The research compares various machine learning algorithms including but not limited to Artificial Neural Networks (ANN), K- Nearest Neighbour, K-Means algorithms. The end result of the research is a valuable tool for the transportation industry. The research will be demonstrated on a case study on Tank Cleaning Time of Chemical Vessel by Utilizing Geospatial data which is an unknown operation time for the maritime transportation industry.

Keywords: Big Data; Data Mining; Transportation

Integration of intermittent and renewable energy sources – Nadia MAÏZI

Optimising workforce and energy costs by exploiting production flexibility

Thibaut Cuvelier, Montefiore, Université de Liège
Quentin Louveaux, Montefiore Institute, Université de Liège

In a world where the electricity prices become more and more volatile, notably due to renewable energies, the industry is suffering from cost variations never seen before, especially when electro-intensive. Nevertheless, the plants can significantly reduce this impact: some electro-intensive factories could shift their production to time periods where the electricity is cheaper, resulting in large savings. At the same time, the grid operator can remunerate this consumption adaptation as a flexibility service. Our research goal is to optimise the operations of a factory around this flexibility. We compute a production plan that adapts to price forecasts, but also flexibility levers that adjust this plan to react to unexpected price changes. We propose the unifying concept of reservoir to provide sufficiently good models for the plant's processes. Nevertheless, this methodology implies to have frequent production plan changes, which directly impacts the workers, as they may be asked to follow barely predictable schedules. This has a significant detrimental effect on their quality of life. As a consequence, the human aspect of flexibility must also be considered: we seek for production plans that consider both workforce and energy costs, and we then assign workers to work shifts while ensuring their well-being. This HR orientation is the most innovative contribution of this research project.

Keywords: Optimization, Industrial; Decision Support Systems; Data Science

Methodology for insertion of intermittent energy in Brazilian hydrothermal dispatch

Fernando Luiz Cyrino Oliveira, Industrial Engineering, Pontifical Catholic University of Rio de Janeiro
Paula Maçaira, Industrial, Pontifical Catholic University
Yasmin Cyrillo, PUC-Rio
Reinaldo Souza, Departamento de Engenharia Elétrica, Pontifícia Universidade Católica do Rio de Janeiro
Fabio Hideki Iha, Risk&Portfolio, CTG Brasil
Luiz Fernando Lorey, CTG

Brazil has almost 5k power generation projects in operation, totaling 161GW of installed capacity, where 66% is from hydroelectric power plants and 6% from intermittent generation sources(wind and solar). An addition of 25 GW is scheduled for the next few years in the country's generation capacity, where 43% of the installed capacity is from intermittent ones. Nowadays, planning the Brazilian energy sector means, basically, making decisions about the dispatch of hydroelectric and thermoelectric plants where the operation strategy minimizes the expected value of the operation cost during the planning period, which is composed of fuel costs plus penalties for failure in supplying the projected expected load. Given the growing trend of intermittent generation in the Brazilian energy matrix, it is necessary to include this type of generation in the dispatch currently used, so that this type of generation is effectively considered in the long term planning. This work aims to develop and apply a methodology called here of Net Demand calculation in order to incorporate intermittent generation in the calculation of the Brazilian hydrothermal dispatch using the analytical method of Frequency and Duration (F&D).In order to extract all the characteristics of intermittent generation, the data periodicity must be hourly, thus providing a model with greater accuracy. The results obtained show that the methodology is successful in including intermittent sources in the hydrothermal dispatch.

Keywords: Applications, Energy; Decision Support Systems; Natural Resources

Real Options in Renewable Portfolio Standards

Makoto Goto, Faculty of Economics and Business, Hokkaido University
Ryuta Takashima, Tokyo University of Science

Recently policymakers have implemented various policies for reducing greenhouse gas emissions, due to concerns about global warming and climate change. Foremost policies for supporting and promoting renewable energy are feed-in tariff (FIT), and renewable portfolio standards (RPS). RPS scheme encourages power producers to supply a certain minimum share of their electricity from renewable energy sources. They create market for renewable energy certificates/credits. According to “Renewables 2016 Global Status Report” by REN21, RPS policies are conducted in 26 countries and 74 states/provinces/territories. RPS policies are popular at the sub-national level. Relationship between RPS scheme and market equilibrium is studied by Fischer (2010), Tanaka and Chen (2013), Siddiqui, Tanaka, and Chen (2016). Boomsma, Meade and Fleten (2012) investigate investment timing and capacity sizing under different support schemes for renewable energy. In this paper, we examine a market equilibrium under uncertainty in RPS by means of real options analysis. More concretely, we analyze an investment timing for renewable producer. After that, we derive optimal RPS target. We have found results about the effect of uncertainty on market equilibrium and optimal RPS target. For fixed RPS target, investment opportunity increases (decreases) with RPS target (uncertainty). For the optimal RPS target, investment opportunity increases with uncertainty. This is a new finding in this area.

Keywords: Applications, Energy; Economic Modeling

Steering the adoption of battery storage through electricity tariff design

Kevin Milis, Engineering Management, University of Antwerp
Herbert Peremans, Engineering Management, University of Antwerp
Steven Van Passel, University of Antwerp

Previous studies have demonstrated that targeted electricity tariff design results in reduction of the annual peak load. The contribution of this paper is that it investigates the economic viability of electricity storage using batteries, under different tariff structures and system configurations using simulations and mixed integer optimization. The economic outcomes of the different combinations of tariff design and system configuration are evaluated using the net-present value over a horizon of 20 years. Starting from a discussion of relevant literature, we elaborate the different tariff designs used in the study: fixed energy prices, real-time energy pricing, fixed rate capacity tariffs, and time dependent capacity tariffs. Next, we outline the chosen system configurations simulated in this paper: no battery storage, battery storage only, and battery storage and decentralized renewable energy production with PV. We use a rolling 24h window in which the total operational cost is minimized using integer programming. Investment costs are taken into account using the NPV method. Our paper outlines the impact of tariff design on the viability of battery storage, and provides insights for policy makers, showing that tariff structures with time dependent components incentivize the investment in battery storage by residential end users, while fixed tariff structures have a negligible impact on these investment prospects.

Keywords: Applications, Energy; Optimization, Interior Point

Maximizing intermittency in 100% renewable and reliable power systems: A holistic approach applied to Reunion Island in 2030

Nadia Maïzi, Center for Applied mathematics, MINES ParisTech
Vincent Mazauric, Strategy & Technology, Schneider Electric
Edi Assoumou, Centre de Mathematiques Appliquees, Mines ParisTech
Vincent Krakowski, MINES ParisTech PSL Research University
Stephanie Bouckaert, Center for applied Mathematics, Mines ParisTech

We address long-term power system analysis taking a comprehensive, coherent approach based on MARKAL-TIMES models. To deal with specific operation conditions, we introduce a transient reliability indicator based on kinetic energy and adapt it to take into account flexibility solutions such as demand response and storage. To constrain operation conditions to their current levels over time, the kinetic indicator is endogenized within the model. In addition, we employ a dedicated Kuramoto model to address the synchronism condition required for aggregating the kinetic energy embedded in the whole power system. This analysis is illustrated by a case study of Reunion Island, which aims to reach energy independence by 2030 using 100% renewables. Although we find that the capacity to invest in the energy sector is doubled, we ascertain that the loss of reliability induced by higher intermittency - typically 50% - in the power mix can be counter balanced and leveraged by implementing flexibility solutions.

Keywords: Applications, Energy; Optimization, Combinatorial; programming, Linear