Operational research in energy and environment

Georgios K. D. Saharidis¹

Published online: 26 September 2017
© Springer-Verlag GmbH Germany 2017

Operational Research has been successfully used in a variety of applications in the field of engineering, energy, environment, transportation, economics, medicine, biology, etc. Although there have been successful efforts in both theoretical and applied domains, there is still a number of outstanding questions regarding: (a) energy and environmental performance (b) energy planning, (c) environmental impact, and (d) sustainability.

In this Special Volume on Operational Research in Energy and Environment, a number of relevant papers provide contributions to both theoretical development and applications in this field. Applications to supply chain, energy and environmental performance and planning, dynamic parking prices, power networks, emissions estimation, as well as theoretical developments on Data Envelopment Analysis, bi-level/multi-criteria optimization, and stochastic programming are addressed.

Data Envelopment Analysis (DEA) widely used approach in operations research. In industrial production processes, decision makers seek certainty in taking optimal decisions. However, because of the uncertainty in a range of factors, the information they obtain always carries some degree of fuzziness. As a result, research in the field of uncertainty has become the leading edge of DEA modeling. Ma-Lin Song et al. based on a DEA approach present fuzzy slacks-based measure (F-SBM) model incorporating a confidence coefficient on the postulation. The model provides a basis for decision making in a wider range of situations to reduce undesirable outputs, control the quantities of pollutants discharged, and improve the environment. In order to quantify the benefits to the environment, an analysis of the

✉ Georgios K. D. Saharidis
saharidis@gmail.com
<http://www.greenyourroute.com/>; http://www.mie.uth.gr/n_one_staff.asp?cid=1&id=243

¹ Department of Mechanical Engineering, University of Thessaly, Pedion Areos, Vólos 38334, Greece

industrial environmental performance of 31 provinces in China is conducted. This analysis shows that the new model is fully consistent with actual conditions. Another work in this domain is presented by Jie Wu et al. An improved DEA model is utilized to evaluate the regional total-factor energy and environmental efficiency of China during the 11th 5-years plan period (2006–2010). An empirical study on 30 of mainland China's provincial-level regions is presented, showing that most of them have low energy and environmental efficiency. On average, eastern China had the highest energy and environmental efficiency, followed by central China, with the efficiency of western China being the worst. The total-factor energy and environmental efficiency is considered using a joint production framework of non-energy inputs (labor and capital) and an energy input (total energy consumption), as well as a desirable output (GDP) and an undesirable output (waste gas). Jiasen Sun et al. integrate game theory and DEA for constructing two variants of an allocation of emission permits (AEP) model among a group of manufacturing companies for controlling the total emission level of the group. The first situation is that all members in the group are cooperative and a reasonable permit allocation scheme should maximize the overall payoff of the group. The second situation is that all group members are non-cooperative and each member makes every effort to selfishly maximize its own payoff. The proposed models are applied to study a group of paper mills to analyze their payoffs. The results show that the proposed methods can provide reasonable allocation results for all firms.

Operational Research has been successfully used in energy planning problems. Fugui Dong and Wen Zhanf evaluate and compare power network plans including distributed photovoltaic generations. The large-scale distributed generation parallel operation may cause deviations of voltage and frequency. Power quality problems, such as voltage fluctuation and flicker, may bring threat to power network safety operation. At the same time, distributed photovoltaic generation is intermittent and impacted by environmental factors. To compare different power network plans including distributed photovoltaic generations, a comprehensive evaluation model is developed at the perspective of a Grid Company based on improved Entropy-Matter-Element extension model. The improved entropy method helps to reflect both the subjective and objective weights, and avoid the problem in traditional entropy weight method, that is, indicators cannot reflect the actual situation.

Another interesting topic in energy planning is the cogeneration of electrical energy and heat which has become a steadily growing and flourishing segment of energy industry. Vítězslav Máša et al. present an analysis of gas microturbine integration in a commercial laundry. The authors opt for a professional laundry care since it is a common representative of a well-known process which requires a lot of energy input. They focus on commercial laundries with a capacity over 1000 kg of processed laundry per shift. This type of laundries is very common and has a large innovation potential. The gas microturbine was considered as a cogeneration unit as it has a process-adequate performance (30 kWe). Its flue gas helps heat main laundry input flows: hot water for the washing machines and hot flue gas for the dryers. Incorporation of a progressive technology with a common commercial process gives a promising application potential.

Cheng Peng et al. present an alternative approach to constructing composite indicators. Existing literature about constructing composite indicators mainly depend on weighting sub-indicators. The authors first use a state-of-the-art MCDM method with mild weights restrictions to aggregate sub-indicators, without determining exact values of weights. They take into consideration all possible importance rankings of sub-indicators for constructing composite indicators. Two alternative approaches, namely, minimizing the total deviation from the ideal point and minimizing the mean absolute deviation, are then proposed to develop weighting schemes with respect to all sub-indicators sequences. A case study for eighteen APEC economies about constructing Sustainable Energy Index is performed to illustrate the effectiveness of the proposed approaches.

Anjali Singh et al. examine which alternative is the most suitable for energy production in a new power plant set up in India. The authors model this problem as a multi-criteria group decision making problem where the criteria values are described in terms of interval-valued 2-tuple linguistic variables. They propose to solve this model by extending the PROMETHEE II method to interval-valued 2-tuple linguistic variables, where the criteria weights in the PROMETHEE II method are supplied using the entropy measure.

Miltiadis Chalikias and Michalis Skordoulis investigate the possibility of applying a widely known mathematical theories of war in firms. In their research, Frederick William Lanchester's combat models is examined. The mathematical model is based on differential equations and its main purpose is to predict the outcome of battles. After the appropriate theoretical conditions were set, the authors apply the model in the case of a supply chain in the duopoly of Coca-Cola and Pepsi in the Greek market. The presented results show that the theoretical models are almost identical to the reality, which means that they can be applied to firms under the right conditions.

In the transportation sector, static and constant price for parking during a day and in all weekdays is not adequate for management dynamic travel demands. The number of trips from the residential districts to the central business district (CBD) is large in the beginning of a day, and low at the end of the day. Hence, parking price must be determined dynamically to shift from private travel mode to public mode. Hamid Reza Eftekhari and Mehdi Ghatee aim to determine the dynamic parking prices in different hours of a day, based on the travel demands. A bi-level optimization model is studied for two types of CBD in order to define the lower bound for dynamic parking prices (LPP) and manage the CBD demand. Based on these prices, the private traffic flows of user equilibrium model or stochastic user equilibrium model converge to the predicted flow derived by system optimum model.

One of the most polluting element of port operations is the use of heavy duty vehicles (HDVs) for the transportation of containers. Konstantzos et al. developed a mathematical model for the quantification of Greenhouse Gas (GHG) emissions produced by HDV during container transport in ports. Most of the existing models used, utilize an over-simplified fuel and energy consumption-based approach. Konstantzos et al., after a critical review of existing emission calculation models, identified potential limitations and chose the modeling approach of COPERT to be

used as a basis for modeling the HDVs fleet in port operation. The authors evaluated and addressed those limitations by introducing new elements and factors such as emissions from stop-and-go traffic, idling time, and emissions increase due to air conditioning operation.

Hierarchical optimization addresses the conflict between two or more decision makers. Bi-level optimization techniques are also used by Chi-Bin Cheng et al. to optimize the operations of the Recycling Fund Management Board (RFMB), founded by the Environmental Protection Administration in Taiwan by using a subsidy rate decision for domestic printer recyclers. The hierarchical and interactive relation between the two parties is modeled by bi-level programming, where the RFMB serves as the upper-level decision unit, recyclers are the lower-level counterpart, and the consumer's action is embedded in the constraints of the lower level problem. The objectives of the RFMB are to maximize the recycling rate, while minimizing its administration expenses and the subsidy given to the recyclers which maximize their profit. To solve the problem, the original model was reformulated as a single level problem by KKT transformation. Practical data including sales of printers per year, a recycling intention survey, the cost structure of recyclers, and the resource recycling value are used to solve the problem. The resulting solution suggests a much lower subsidy rate than the current rate provided by the RFMB but is still able to yield a recycling rate that is slightly greater than the current one.

Stochastic goal programming method is an alternative approach to model real-world optimization problems which involve conflicting criteria. Raja Jayaraman et al. present a scenario-based stochastic goal programming model with Satisfaction Function that integrates optimal employee allocation to simultaneously satisfy conflicting criteria related to economic development, energy consumption, work-force allocation, and greenhouse gas emission (GHG) emissions. The work emphasizes the importance of multi-criteria techniques as a critical tools for policy planning and economic analysis relating to sustainable development. The results of the model strongly justify the ongoing and planned investments in renewable and low emitting sources of energy to augment the growing demand of electricity ensuring the long run stability of the UAE's sustainability targets.

We hope that this special issue will stimulate both theoretical and applied research in the related fields of energy and environment. We would like to thank the authors that have contributed to this special issue, the reviewers who have graciously provided their valuable time and effort to ensure the quality of the papers finally accepted. We are most thankful to Prof. Nikolaos Matsatsinis, Editor in Chief of *Operational Research: An International journal* for given us the opportunity to arrange this special issue, and to the Springer staff for their support.