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Opinion Makers Section

Multi-Objective Optimization and Multi-Criteria Decision Analysis in the Energy Sector (part I – MOO)

Carlos Henggeler Antunes (1,2) – e-mail: ch@deec.uc.pt

(1) Dept. of Electrical Engineering and Computers, University of Coimbra, Polo II, 3030-290 Coimbra, Portugal

(2) INESC Coimbra, Rua Antero de Quental 199, 3000-033 Coimbra, Portugal

Abstract - The energy sector has been a fertile ground for the application of operational research (OR) models and methods (Antunes and Martins, 2003). Even though different concerns have been present in OR models to assess the merit of potential solutions for a broad range of problems arising in the energy sector, the use of multi-objective optimization (MOO) and multi-criteria decision analysis (MCDA) approaches is more recent, dating back from mid-late 1970s. The need to consider explicitly multiple uses of water resource systems or environmental aspects in energy planning provided the main motivation for the use of MOO and MCA models and methods with a special evidence in scientific literature since the 1980s. The increasing need to account for sustainability issues, which is inherently a multi-criteria concept, in planning and operational decisions, the changes in the organization of energy markets, the conflicting views of several stakeholders, the prevalent uncertainty associated with energy models, have made MOO and MCA approaches indispensable to deal with complex and challenging problems in the energy sector (Diakoulaki et al., 2005; Antunes et al., 2014).

1. Introduction

The capability of reliable provision of energy to meet a vast range of needs and requirements in residential, services/commerce, agriculture, industrial and transportation sectors, is one of the most distinctive features of modern developed societies. From supplying power and heat to production systems to satisfying heating, cooling, lighting, and mobility needs, energy is pervasive in everyday life. Until mid 1970s, when an energy crisis occurred caused by the peaking of oil demand in major industrial nations and embargoes from producer countries, energy planning was almost exclusively driven by cost minimization models subject to demand satisfaction and technology constraints. This paradigm, in which per capita energy consumption was an index of a nation's prosperity, started to change due to the energy crises in the 1970s and also the growing concerns regarding environmental impacts associated with the energy life-cycle from extraction, including the depletion of fossil resources, to end-use. Therefore, the merits of energy plans and policies could not be judged by considering just economic costs, but other evaluation aspects such as reliability of supply, environmental impacts, source diversification, etc., should be explicitly taken into account to address energy problems in a societal perspective. Although issues other than economic costs were often present at the outset of some studies, usually those concerns were then amalgamated into an overall cost dimension by monetizing, for instance, environmental impacts and energy losses, rather than operationalizing those multiple, incommensurate and conflicting evaluation axes as expressing distinct perspectives of the merits of courses of action.

In this context, MOO and MCDA models and methods naturally gained an increasing relevance and acceptance in the appraisal of energy technologies and policies in a vast range of energy planning problems at different decision levels (strategic, tactical, operational) and timeframes (from long-term planning to near real-time control). The recognized need and advantages of explicitly using multiple objectives/criteria not just provided a value-added in exploring a larger range of possible decisions embodying different trade-offs between the competing axes of evaluation but also enabled a richer critical analysis of potential solutions. Furthermore, this modeling and methodological framework made possible to include the preferences and interests of multiple stakeholders in a coherent manner into the decision process, to increase solution acceptance, and the several sources of uncertainty at stake, to obtain more robust recommendations.

Two major trends may be identified, which have a strong impact of MOO/MCA research and practice on the energy sector: the increasing awareness of the need to ensure sustainable development, in which energy provision plays a key role, and the trend for liberalization and market deregulation, at least in some industry segments. The concern of sustainable provision of energy meeting the present needs without compromising the ability of future generations to meet their needs is inescapable in the development of decision support models in the energy sector. Sustainability is inherently a multi-criteria concept, which makes MOO/MCA approaches indispensable to deal with the complex and challenging problems arising in the energy sector. The exploitation of energy resources must be balanced with the threats of climate change, mitigation of impacts on human health and natural ecosystems, assessment of geo-political risks, etc., also recognizing the uncertainty, the long-term and possible large-scale effects of today's energy decisions. Technologies that promote sustainable energy include renewable energy sources, such as hydroelectricity, solar energy, wind energy, wave power, geothermal energy, and tidal power, and also those designed to improve energy efficiency. Besides the important investments at stake in several energy decisions, these embody also complex and controversial issues related to global and inter-generational effects for which the MOO/MCA toolbag offers the methodological instruments to reach balanced decisions due to their ability to combine sound models and methods with subjective judgments and perspectives of reality.

For many years companies in the energy industry were generally vertically integrated, although at different degrees, i.e. owning generation plants, transmission and distribution networks, and customer access equipment including billing services. Most of these companies were, and still are in several cases, state-owned with the aim of protecting public interests in face of the essential nature of provision of energy, namely gas and electricity. The main aim of deregulation, whether involving or not privatization, was encouraging competition in many areas to curb economic inefficiencies associated with the operation of energy monopolies. In general, in the (more or less concentrated) wholesale electricity markets competing generators offer their electricity production to retailing companies, which then sell it to clients. In the retail markets end-use clients are able to select their supplier from competing retailing companies.

Models and methods to address end-users' demand response to reduce peak demand and energy bill are currently a challenging research area in which MOO/MCA models and methods are being used. The technological improvements enabling small-scale production of electricity is also expected to introduce further changes in the industry, since the prosumer (i.e., simultaneously producer and consumer) will expectedly be able to manage demand, have a local micro/mini generation facility (e.g., a small wind turbine or photovoltaic panels), store energy in static batteries or in an electric vehicle, and buy from or sell electricity back to the grid. Therefore, new and challenging decision contexts emerge at different energy industry levels, which should balance economic efficiency, environmental concerns, social interests, and technological issues.

The first historical applications of MOO/MCA in energy planning date back to the late 1970s, namely concerning power generation expansion planning or the choice of sites for nuclear and fossil-fired generation plants. As the relevance of MOO/MCA models was recognized, a vast amount of literature reported new models, algorithmic approaches and real-world applications to several problems, also witnessing the need to take duly into account problem structuring techniques to shape problems to be tackled and dealing with uncertainty with the aim to obtain robust conclusions (Hobbs and Meier, 2000; Greening and Bernow, 2004; Diakoulaki et al., 2005; Løken, 2007; Wang et al. 2009; Alarcon-Rodriguez et al., 2010; Antunes et al., 2014). Greening and Bernow (2004) even advocated the implementation of several multi-criteria methods in an integrated assessment framework for the design of coordinated energy and environmental policies.

In MOO, mathematical programming models are developed consisting of multiple objective functions to be optimized in a feasible region defined by a set of constraints, with different types of decision variables (binary, integer, continuous, etc.). In MCA a limited number of courses of action (alternatives) are, in general, explicitly known a-priori to be evaluated according to multiple evaluation criteria, possibly organized as a hierarchical criterion tree, and the performances of the alternatives may be qualitatively and/or quantitatively expressed using different types of scales (ratio, interval, etc.) thus leading to a bi-dimensional impact matrix (alternatives vs. criteria). MOO/MCA approaches are essential for a thorough analysis of a vast range of problems in the energy sector at different decision levels and with different timeframes in order to generate usable recommendations that balance multiple, conflicting and incommensurate evaluation aspects.

2. Multi-objective optimization models and methods

MOO models and methods have been used to deal with a large variety of energy problems at different organizational levels and timeframes. A common distinction is made between long-term/strategic, operational and short-term problems (Table 1).

Planning	Typical timeframe	Examples of decisions to be made
Long-term/Strategic	Several years-decades	Generation expansion planning Transmission facility expansion Siting of new power plants Energy-environment-economy models Market design
Operational	Months-years	Generation scheduling Transmission scheduling Reactive power planning
Short-term	Hours-days-weeks	Unit commitment Power flow Demand-side management

Table 1. Categories of planning problems in power systems according to the organizational level and timeframe

2.1. Power generation planning

Power generation capacity expansion planning was one of the first problems to be addressed using MOO, initially as an extension of single objective cost minimization models. As environmental issues gained an increasing attention, models began to include them as explicit objective functions rather than encompassing them in an overall cost function by using, for instance, monetized pollutant emissions associated with power generation. In these problems the aim is, in general, identifying the amount of power to be installed (number and type of generating units, that is, primary energy source and energy conversion technology, sometimes also involving siting decisions) and output (energy to be produced by new and already installed units) throughout a planning period, in general of a few decades. With the development of renewable energy resources, technologies for power generation expansion involve coal units, large scale and small hydro units, conventional and combined cycle natural gas units, nuclear plants, wind farms, geothermal units, photovoltaic units, etc.

The objective functions include the minimization of the total expansion cost (or just production costs), the minimization of pollutant emissions (SO2, CO2, NOx, etc.), the maximization of the system reliability/safety, the minimization of outage cost, the minimization of radioactive wastes produced, the minimization of the external energy dependence of the country, the minimization of a potential technical risk/damage indicator, the minimization of option portfolio investment risk, the minimization of fuel price risks, and the maximization of employment at national or regional level. The constraints mainly express generation capacity lower/upper bounds, minimum load requirements, satisfaction of forecasted demand including a reserve margin, resource availability, technology restrictions due to technical or political reasons (e.g., the amount of nuclear power allowed to be installed), domestic fuel quotas, energy security (as a surrogate for diversification of the energy supply), committed power limits, budgetary limitations, operational availability of generating units, rate of growth of the addition of new capacity, transmission constraints due to generation units placement, coal/gas production and transportation capacities, need to account for multiple water uses and capacity in hydro reservoirs, pumping capacities. Multiple-use hydroelectric systems, and in particular multi-reservoir cascaded systems, impose additional issues to be considered, either as objective functions or constraints, such as competition of different operators on the same basin (scheduling of reservoirs) and balancing energy and non-energy uses, including dam safety, discharges and spills, flood protection and control, agriculture irrigation, industrial and domestic water supply, navigation, dilution of pollutants and heated effluents, recreation, ecological sustainability and protection of species, etc. Pollutant emissions materialize either expressed as constraints in physical quantities (tons), in general reflecting (national or international) legislation, or (surrogate) environmental objective functions consisting in aggregate indicators penalizing the installed capacity and the energy output. Besides considering conventional and renewable supply-side options, some models adopt a broader perspective of integrated resource planning by also including demand-side options in the planning process, which are aimed at shaping the load diagram in such a way that peaks are flattened and valleys are filled.

The algorithmic approaches to tackle generation capacity expansion planning models are very diversified and in some way denote the trend from "classical" MOO approaches, both generating methods to characterize as exhaustively as possible the non-dominated solution set and interactive methods using the preference information expressed by decision makers/planners to guide and reduce the scope of the search, to multi-objective meta-heuristics and, in particular, multi-objective genetic/evolutionary algorithms. The use of MOMILP models led to the development of MOO algorithms based on branch-and-bound or cutting planes, in general aimed at characterizing the whole non-dominated solution set. In general, in "classical" approaches a single non-dominated solution is generated through the optimization of a surrogate scalar(izing) function that temporarily aggregates the original multiple objectives also including preference information parameters, in such a way that the optimal solution to this function is non-dominated to the MOO model. Population-based meta-heuristics (genetic/evolutionary algorithms, particle swarm optimization, differential evolution, etc.) are often justified, besides the combinatorial complexity of the problems, on the grounds that using a population of solutions that expectedly converge to the true non-dominated front (which is generally unknown) is more efficient than resorting to the optimization of scalarizing functions. Several sources of uncertainty are at stake in these power generation expansion planning models, namely concerning demand growth, primary energy prices, inflows to hydro reservoirs, etc., and even regulations. The uncertainty associated with the model coefficients is usually modeled through stochastic coefficients or, in fewer cases, fuzzy sets, and models are then tackled by means of stochastic or fuzzy programming. Also, scenarios to which a probability distribution is assigned are sometimes used, those embodying sets of plausible instantiations of uncertain model elements, such as the ones mentioned above. The paradigm of robust solutions is also used, in the sense that the variation in objective functions, and even constraints, is within acceptable ranges for uncertain model coefficients and parameters, thus displaying a certain degree of "immunity" of solutions to "moderate" changes in the inputs. Since these types of prior incorporation of uncertainty in the mathematical model leads, in general, to a significant additional computational burden to obtain solutions, uncertainty may be also tackled by performing (a posteriori) sensitivity analysis of selected compromise solutions.

2.2. Network planning

The network infrastructure (both transmission and distribution) plays a critical role in providing energy to consumers. When utilities were vertically integrated, thus owning transmission network and generation assets, the planning process was generally integrated. Being the sole provider of services along the whole industry chain, utilities had complete data and forecasting capability about demand and its evolution. The complete knowledge about decisions concerning the installation of new generation units or the retirement of existing ones enabled also a more controlled planning of the transmission network. Since nowadays generation and transmission are usually separated by means of functional unbundling or company split, and due to competition in electricity generation, transmission network planning is a more complex task. Focusing on power networks, the transmission network has a central position in system operations and wholesale markets. Transmission network planning models are aimed at determining the location, the size and the time frame of the installation of new circuit additions to supply the forecasted load throughout the planning period, considering economic, environmental, technical and quality of service objectives subject to operating constraints given the existing network configuration and generation units.

Aspects generally contemplated either as objective functions or constraints are: economic – construction/reinforcement costs, equipment (transformer stations, protection devices, etc.) upgrade costs, congestion costs, energy losses costs, regional or national economic growth induced by projects, facilitating competitive wholesale markets; environmental - impacts of line corridors, effects on location of power plants, need to account for remote disperse renewable generation; technical - network topology, inter-control area flows, reliability standards associated with thermal, voltage and stability requirements; quality of service indicators – system/customer average interruption frequency/duration indices, momentary average interruption frequency index; public health - population exposure to electromagnetic fields. Distribution networks carry electric energy from transmission networks to customers. Distribution Network Operators are generally organized on a geographical basis and should provide a reliable operation complying with technical and quality of service parameters, taking into account the dynamics of end-use loads at different time frames. The network distribution planning should also support the operation of electricity market by enabling non-discriminatory access to the network. The introduction of dispersed renewable generation, sometimes at the distribution network level, is changing the distribution network planning process since this now needs to accommodate not just traditional and new loads (for instance, the electric vehicle) but also micro- and mini-generation facilities. The ongoing evolution to smart grids, offering the technological basis using sophisticated Information and Communication Technologies to accommodate responsive demand, storage, and local generation, creates new challenges regarding distribution network planning in a more dynamic stance taking into account the integrated management of supply and demand resources.

2.3. Reactive power planning

The reactive power compensation planning problem involves determining the location and size of capacitors to be installed in electrical distribution networks, which are generally operated in a radial structure, to guarantee an efficient delivery of active power to loads, releasing system capacity, reducing system losses, and improving bus voltage profile, thus promoting economic and operational/quality of service benefits. This leads to non-linear models with binary and continuous variables.

Objective functions generally express investment, installation, and operation and maintenance costs, power losses, economical operating conditions, system security margin (line overloads due to excessive power flow), voltage deviation from the ideal voltage at buses and quality of service indicators. More recent methods to deal with this problem are based on meta-heuristics to cope with its combinatorial nature, namely population based approaches devoted to MOO models, such as genetic algorithms, particle swarm optimization and differential evolution.

2.3. Unit commitment

The unit commitment problem consists in scheduling generating power plants to be on, off, or in stand-by mode, within a planning period to meet demand load. When the power system is vertically integrated, unit commitment is carried out by the utility in a centralized manner and the objective function is minimizing overall costs subject to meeting demand and reserve margins. When generation is under competition, a generation company must decide locally the unit commitment plan in order to maximize its profit taking into account established power contracts and the energy it estimates it may sell in a competitive (spot) market according to price forecasts. Technical constraints such as capacity constraints, stable operating levels, minimum time period the unit is up and/or down, or maximum rate of ramping up or down should be included in mathematical models.

Economic dispatch problems consist in determining the optimal combination of power output of online generating power plants to minimize the total fuel cost while satisfying load demand and operational constraints. Since load demand can vary swiftly, dispatch should be able to react and adapt while guaranteeing adequate cost or profit levels, considering technical issues such as voltage control, congestion, transmission losses, line overloading, voltage profile, deviations of technical indicators from standard values. Also, particular market structures should be taken into account. While a generation company in a competitive environment intends to maximize profits, entities such as an independent system operator aims at maximizing social welfare, and these perspectives should be reconciled in decision aid models. Economic-environmental dispatch generally leads to MOO models in which cost minimization, or profit maximization, and environmental impact minimization (namely harmful emissions originated at fossil-fuel power plants) are considered.

2.4. Demand side management

Demand-side resources have been used by utilities with the main goals of achieving cost reduction and operational benefits (such as reducing peak power demand, improving reliability, increasing load factor, or reducing losses), which maintain their potential attractiveness even in an unbundled electricity industry. Appropriate power curtailment actions impose changes on the regular working cycles of loads to reduce peak demand without compromising the quality of the energy services provided, either by interrupting loads through direct load control or voluntary load shedding, shifting their operation cycles to other time periods or changing operating settings (such a thermostats). The goal is to design and select adequate load management actions, considering a comprehensive set of objectives of different nature (economic, technical, comfort, quality of services) and different players in the power industry. Since the energy service provided by loads under control is changed, possibly postponed or even not provided at all, when load management actions are implemented, attention should be paid to discomfort caused to customers so that those actions become also interesting for them, namely due to the ensuing reduction in their electricity bill. Therefore, multiple incommensurate and conflicting objectives of economical, technical and quality of service nature are at stake in the design and selection of load management actions. These aspects are modeled as either hard or soft constraints (by establishing thresholds whose violation is included into a penalty function).

2.5. Energy-economy-environment interactions

The study of the interactions between the economy (at national or regional levels), the energy sector and the corresponding impacts on the environment inherently involves multiple axes of evaluation of distinct policies. In general, MOO models for this purpose are developed based on input-output analysis (IOA) or general equilibrium models (GEM). The analytical framework of IOA enables to model the interactions between the whole economy and the energy sector, thus identifying the energy required for the provision of goods and services in an economy and also quantifying the corresponding pollutant emissions. GEM include interrelated markets and represent the (sub-)systems (energy, environment, economy) and the dynamic mechanisms of agent's behavior to compute the competitive market equilibrium and determine the optimal balance for energy demand/supply and emissions/abatement.

2.6. Energy markets

The liberalization of energy markets is aimed at increasing overall efficiency through the introduction of competition in some of the industry branches, namely generation and retailing. The underlying idea is that by enhancing efficiency and productivity gains, lower energy (namely electricity) prices and lower production costs are achieved. This trend of energy markets should go in line with security of supply (by minimizing risks and overall impacts of supply disruptions, diversifying energy sources including renewables and energy efficiency), competitive energy systems (to minimize energy costs for consumers and industry, thus contributing to social policies and economic competitiveness), and environmental protection (thus minimizing the impacts of energy generation and use on populations and ecosystems). Issues such as the internalization of external costs to the environment into energy prices, in accordance with the polluter pays principle, are also at stake in designing market-based mechanisms balancing multiple objectives, such as taxes or tradable emission permits.

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MCDA Research Groups

Environmental sustainability and Multicriteria Decision Aiding

by Marta Bottero and Valentina Ferretti

Department of Urban and Regional Studies and Planning, Politecnico di Torino, Torino, Italy
marta.bottero@polito.it; valentina.ferretti@polito.it

The research group on "Environmental sustainability and Multicriteria Decision Aiding" is composed by Dr. Marta Bottero, Dr. Valentina Ferretti and Professor Giulio Mondini. The group works at the Department of Urban and Regional Studies and Planning of the Politecnico di Torino (Italy) in the general scientific domain of Project Appraisal and Planning Evaluation. Having backgrounds in Environmental Engineering and Sustainable Architecture, the main interests of the group are related to sustainability assessment and environmental decision-making in the context of projects, plans and programmes, with multiple research directions in MCDA. Overall, the work is inspired by real life applications.

It is well known that sustainable development is a multidimensional concept which includes socio-economic, ecological, technical and ethical perspectives. Decision problems in the domain of sustainability assessment represent "weak" or unstructured problems since they are characterized by multiple actors, many and often conflicting values and views, a wealth of possible outcomes and high uncertainty (Prigogine, 1997; Simon, 1969). Under these circumstances, the evaluation of alternative projects is therefore a complex decision problem where different aspects need to be considered simultaneously, taking into account both technical elements, which are based on empirical observations, and non technical elements, which are based on social visions, preferences and feelings.

Projects, plans and programmes are subject to specific evaluation procedures, which aim at assessing the overall sustainability of the proposed solutions. In this context, mention can be made to the Environmental Impact Assessment (EIA) and Strategic Environmental Assessment (SEA), which are defined at the European level by the Directives 1997/11/EC and 2001/42/EC, respectively. Both EIA and SEA over time have increasingly considered not only the environmental effects of plans and projects, but also social and economic effects. In this context, it has been noticed that neither an economic reductionism nor an ecological one is possible (Munda, 2005). Since in general, economic sustainability has an ecological cost and ecological sustainability has an economic cost, an integrative evaluation framework is needed for tackling sustainability issues properly.

The objective of the group, which is very active in applied research, is to investigate the role of Multicriteria Decision Aiding in decision processes related to environmental sustainability. Starting from real-world problems, the focus of the research concerns the experimentation of MCDA methods with the objective of supporting the Decision Makers in solving complex choices about territorial projects, considering the full range of aspects of the decision problem and the opinion of the different stakeholders that can be affected by the project.

Many MCDA methods have been considered by the research group over the years, including Analytic Hierarchy Process/Analytic Network Process (AHP/ANP), Dominance-based Rough Set Approach (DRSA), Multicriteria – Spatial Decision Support System (MC-SDSS), Choquet integral, Non Additive Robust Ordinal Regression (NAROR), Electre III and Multi Attribute Value Theory (MAVT). In most of these experimentations, the research group made use of the collaboration with the Higher Institute on Territorial Systems for Innovation (SiTI, www.siti.polito.it) which provided numerous case studies and expert knowledge for the research of the group.

As far as AHP/ANP methodology is considered, the experimentation was developed in the field of architecture and environmental engineering. Mention has to be made to the fact that the group followed the research work developed in the past years by prof. Riccardo Roscelli from the Politecnico di Torino in the field of AHP and regional and urban planning. Particularly, the research group made use of the methodology for leading the choice of alternative projects for the construction of a skyscraper in Torino or for addressing the selection of the most sustainable technology in the case of waste water management. It is also interesting to recall the application of this theory in the domain of spatial planning where the ANP was proposed for supporting the participative procedure related to the development of a Municipal Plan. With specific reference to the ANP theory, joint research works were developed with the collaboration of two colleagues of the same Department, Dr. Isabella Lami and prof. Patrizia Lombardi, with different applications especially in the field of transport planning.

With reference to the DRSA theory, the research has been conducted with the collaboration of prof. Salvatore Greco from University of Catania and other colleagues from the same Department, Dr. Isabella Lami and Dr. Francesca Abastante. In this case, the investigation considered the application of the DRSA theory in different domains, including transport planning and undesirable facilities location. The results of the applications showed that DRSA offers a useful tool for reasoning about the data involved in the decision problem at hand and that it is suitable to elicitate the DMs' preferences and to support them by explaining and justifying the final choice.

Another research direction of our group refers to the development and application of Multicriteria- Spatial Decision Support Systems. The integrated approach based on the combination between Multicriteria Analysis and

Geographic Information Systems to support Environmental Impact Assessment and Strategic Environmental Assessment procedures has been the focus of the Ph.D. thesis of Valentina Ferretti who has tested the approach in both the context of undesirable facilities location (i.e. landfill and incinerator plants) and ecological connectivity analysis. Recent developments of her research, in a joint effort together with Dr. Gilberto Montibeller (London School of Economics) are trying to formalize the main challenges which characterize spatial multicriteria evaluation. The Turin research group has also collaborated with Dr. Elena Comino and Dr. Maurizio Rosso, two colleagues from the Department of Environment, Land and Infrastructure Engineering, and Dr. Silvia Pomarico, a former Ph.D. student, for the application of this integrated approach to study biodiversity conservation and ecosystems value.

Working in the field of environmental sustainability assessments, the decision problems that we are analysing are often characterized by interacting elements (i.e. the environmental components such as air, water, land, etc.). Being interested in investigating these interactions, we studied the Choquet Integral approach and we applied it in the context of undesirable facilities management and location (e.g. the requalification of an abandoned quarry and the selection of the most compatible site for a new incinerator plant). Following this interest, we started investigating the Non Additive Robust Ordinal Regression (NAROR) together with Isabella Lami from our Department and a research group at the University of Catania coordinated by Professor Salvatore Greco and including Dr. Salvatore Corrente and Dr. Silvia Angilella. With reference to this last methodological approach, mention has to be made to the fact that we developed the first real application of the NAROR and implemented it for the location of an urban waste landfill in Northern Italy.

Speaking about criteria interaction, the very recent research of the group are focusing on the study and real application of the extension of the ELECTRE III method to take into account interactions between criteria. In this case, the group is collaborating with Professor Bernard Roy (LAMSADE, Paris), Professor José Rui Figueira (University of Lisbon) and Professor Salvatore Greco (University of Catania, Italy) for testing this innovative approach in the context of environmental decision-making problems.

Another research direction that the group is now considering is related to the study of the Multi- Attribute Value Theory. In this context, the method has been tested in two participative contexts referring to the requalification of a downgraded urban area and to the management of the cultural heritage in the Province of Turin.

Future research lines of the group would further investigate the existence of interaction among criteria with specific reference to the use of environmental and landscape indicators and indexes. Another research direction would study in depth the use of Spatial Multicriteria Analysis for supporting the design of territorial transformation scenarios. Through the adoption of an approach of the type "value-focused thinking" future studies would be directed towards the use of stakeholders analysis, participation procedures and group decision-making.

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Forum

The Robustness Concern in Preference Risaggregation Approaches for Decision Aiding

Michael Doumpos[1], Constantin Zopounidis[1, 2]

1 Technical University of Crete, Dept. of Production Engineering and Management, Financial Engineering Laboratory, University Campus, 73100 Chania, Greece

2 Audencia Group, School of Management, Nantes, France

INTRODUCTION

Similarly to other operations research/management science modeling approaches, MCDA techniques are also based on assumptions and estimates on the characteristics of the problem, the aggregation of the decision criteria, and the preferential system of the decision-maker (DM). Naturally, such assumptions and estimates incorporate uncertainties and errors, which affect the recommendations provided to the DM. Thus, changes in the decision context, the available data, or a reconsideration of the decision criteria and the goals of the analysis, may ultimately require a very different modeling approach leading to completely different outputs. Therefore, even if the results may be judged satisfactory when modeling and analyzing the problem, their actual implementation in practice often leads to new challenges not taken previously into consideration.

In this context, robustness analysis has emerged as a major research issue in MCDA. Robustness analysis seeks to address the above concerns through the introduction of a new modeling paradigm based on the idea that the multicriteria problem structuring and criteria aggregation process should not be considered in the context of a well-defined, strict set of conditions, assumptions, and estimates, but rather as a process that aims towards providing satisfactory outcomes even in cases where the decision context is altered.

Vincke (1999) emphasized that robustness should not be considered in the restrictive framework of stochastic analysis and distinguished between robust solutions and robust methods. He further argued that although robustness is an appealing property, it is not a sufficient condition to judge the quality of a method or a solution. Roy (2010), on the other hand, introduced the term robustness concern to emphasize that robustness is taken into consideration a priori rather than a posteriori (as is the case of sensitivity analysis). In the framework of Roy, the robustness concern is raised by vague approximations and zones of ignorance that cause the formal representation of a problem to diverge from the real-life context.

The robustness concern is particularly important in the context of the preference disaggregation approach (PDA) of MCDA, which is involved with the inference of preferential information and decision models from data (Jacquet-Lagrèze and Siskos, 2001). Disaggregation techniques facilitate the construction of multicriteria evaluation models, using decision examples that the DM provides, without requiring the specification of complex parameters whose concept is not clearly understood by the DM. In particular, using as input a set of decision examples involving the DM's evaluation of some reference alternatives (reference set), disaggregation approaches use optimization formulations to infer the parameters of a decision model such that the outputs of the model are consistent with the DM's evaluations on the reference set. This is a regression-based approach, in which the robustness of the inferred model and the obtained recommendations depend on a number of issues related to the specification of the reference set and the form of the decision model.

ROBUSTNESS ISSUES IN DISAGGREGATION APPROACHES

The quality of models resulting from disaggregation techniques is usually described in terms of their accuracy, which can be defined as the level of agreement between the DM's evaluations and the outputs of the inferred model. Except for accuracy-related measures, however, the robustness of the inferred model is also a crucial feature. Recent experimental studies have shown that robustness and accuracy are in fact closely related (see for example, Vetschera et al., 2010). However, accuracy measurements are done ex-post and rely on the use of additional test data, while robustness is taken into consideration ex-ante, thus making it an important issue that is taken into consideration before a decision model is actually put into practical use.

The robustness concern in the context of PDA arises because multiple alternative decision models can be inferred in accordance with the information embodied in the set of reference decision examples that a DM provides. The diversity of the set of compatible decision models depends on a number of factors, but the two most important ones can be identified with respect to the adequacy of set of reference examples and the complexity of the selected decision modeling form. The former is immediately related to the quality of the information on which model inference is based. Vetschera et al. (2010) performed an experimental analysis to investigate how the size of the reference set affects the robustness and accuracy of the resulting multicriteria models in classification problems. They found that small reference sets (e.g., with a limited number of alternatives with respect to the number of criteria) lead to decision models that are neither robustness nor accurate. Expect for its size other characteristics of the reference set are also relevant, such as the existence of noisy data, outliers, the existence of correlated criteria, etc. (Doumpos and Zopounidis, 2002).

The complexity of the inferred decision model is also an issue that is related to its robustness. Simpler models (e.g., a linear value function) are more robust compared to more complex non-linear models. The latter are defined by a larger number of parameters and as a result the inference procedure becomes less robust and more sensitive to the available data.

APPROACHES FOR ROBUST DISAGGREGATION ANALYSIS

The research in the area of building robust multicriteria decision models and obtaining robust recommendations with disaggregation techniques can be classified into three main directions. The first, involves approaches that focus on describing the set of feasible decision models with analytic or simulation techniques. The second focuses on procedures for formulating robust recommendations through multiple acceptable decision models, whereas a third line of research has focused on techniques for selecting the most characteristic (representative) model from the set of all models compatible with the information provided by the reference set. The following subsections discuss these approaches in more detail.

Describing the set of acceptable decision models

The DM's evaluations for the reference alternatives provide information on the set of acceptable decision models that comply with these evaluations. Searching for different solutions within this feasible set and measuring its size provides useful information on the robustness of the results. Analytic and simulation-based techniques have been used for this purpose, focusing on convex polyhedral sets for which the analysis is computationally feasible.

Jacquet-Lagreze and Siskos (1982) were the first to suggest the analysis of multiple decision models compatible with the DM's evaluations (or even alternative near-optimal ones in the cases of inconsistent reference sets). The approach they suggested was based on a heuristic post-optimality procedure seeking to identify some characteristic alternative models corresponding to corner points of the feasible polyhedron. Despite their simplicity, post-optimality techniques provide only a limited partial view of the complete set of models that are compatible with the DM's preferences. A more thorough analysis requires the implementation of computationally intensive analytic or simulation approaches. The latter have gained much interest in the context of robust decision aiding. Originally used for sensitivity analysis (Butler et al., 1997) and decision aiding in stochastic environments (Lahdelma and Salminen, 2001), simulation techniques have been recently employed to facilitate the formulation of robust recommendations under different decision modeling forms. For instance, Tervonen et al. (2009) used such an approach to formulate robust recommendations with the ELECTRE TRI method, whereas Kadziński and Tervonen (2013a, 2013b) used a simulation-based approach to enhance the results of robust analytic techniques obtained with additive value models in the context of ranking and classification problems.

Robust decision aid with a set of decision models

Instead of focusing on the identification of different evaluation models that can be inferred from a set of reference decision examples through heuristic, analytic, or simulation approaches, a second line of research has been concerned with how robust recommendations can be

formulated by aggregating the outputs of different models and exploiting the full information embodied in a given set of decision instances.
Siskos (1982) first introduced the idea of building fuzzy preference relations based on a set of decision models inferred with a preference disaggregation approach for ordinal regression problems. Recently, this idea has been further extended to consider not only a subset of acceptable models but all models that can be inferred from a given reference set, without actually identifying them. This approach has been used for ordinal regression (Greco et al., 2008) and classification problems (Greco et al., 2010) with additive value function models, as well as with and non-additive value models (Angilella et al., 2010) and outranking models (Greco et al., 2011, Kadziński et al., 2012, Corrente et al., 2013).

Selecting a representative decision model

Having an analytic or simulation-based characterization of all compatible models provides the DM with a comprehensive view of the range of possible recommendations that can be formed on the basis of a set of models implied from some decision examples. On the other hand, a single representative model is easier to use as it only requires the DM to "plug-in"' the data for any alternative into a functional, relational, or symbolic model. Furthermore, the aggregation of all evaluation criteria in a single decision model enables the DM to get insight into the role of the criteria and their effect on the recommendations formulated through the model.
In this context several approaches have been introduced to infer a single decision model that best represents the information provided by a reference set of alternatives. Traditional disaggregation techniques such as the family of the UTA methods (Siskos and Grigoroudis, 2010) use post-optimality techniques based on linear programming in order to build a representative additive value function defined as an average solution of some characteristic models compatible with the DM's judgments, defined by maximizing and minimizing the criteria trade-offs. Such an averaging approach provides a proxy of the center of the feasible region. However, given that only a very few number of corner points are identified with this heuristic post-optimality process, the average solution is only a very rough "approximation" of the center of the polyhedron. Furthermore, the optimizations performed during the post-optimality analysis may not lead to unique results.
A number of alternative approaches have been proposed to address the ambiguity in the results of the above post-optimality process. Beuthe and Scannella (2001) presented different post-optimality criteria in an ordinal regression setting to improve the discriminatory power of the resulting evaluating model. Similar criteria were also proposed by Doumpos and Zopounidis (2002) for classification problems.
Alternative optimization formulations have also been introduced allowing the construction of robust decision models without requiring the implementation of post-optimality analyses. Following this direction, Doumpos and Zopounidis (2007) presented modifications of traditional optimization formulations on the grounds of the regularization principle which is widely used in data mining and statistical learning (Vapnik, 2000). On the other hand, Bous et al. (2010) proposed a formulation for ordinal regression problems that enables the construction of an evaluation model through the identification of the analytic center of the polyhedron form by the DM's evaluations on some reference decision instances. In a different framework, Greco et al. (2011) considered the construction of a representative model through an interactive process, which is based on the grounds of preference relations inferred from the full set of models compatible with the DM's evaluations. During the proposed interactive process, different targets are formulated, which can be used by the DM as criteria for specifying the most representative evaluation model.

CONCLUSIONS AND PERSPECTIVES

PDA techniques greatly facilitate the development of multicriteria decision aiding models, requiring the DM to provide minimal information without asking for the specification of complex technical parameters which are often not well-understood by DMs in practice. However, using such a limited amount of data should be done with care in order to derive meaningful and really useful results. Robustness is an important issue in this context. Addressing the robustness concern enables the formulation of recommendations and results that are valid under different conditions with respect to the modeling conditions and the available data. In this article we briefly outlined the main aspects of robustness in PDA and the different lines of research that have been developed in this area.
Future research should focus on the further theoretical and empirical analysis of the robustness properties of PDA formulations, the introduction of meaningful measures for assessing robustness, the development of methodologies to improve the robustness of models and solutions in decision aid, and the exploitation of the recent developments in areas such as robust optimization (Bertsimas et al., 2011).

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Persons and Facts

In the 22nd International Conference on Multiple Criteria Decision Making 17-21 June 2013 - Málaga (Spain), the 2013 awardees were:
- MCDM Gold Medal: Salvatore Greco.
- Edgeworth-Pareto Award: Constantin Zopounidis.
- Georg Cantor Award: João Climaco.
- MCDM Doctoral Disseration Award: Miłosz Kadziński

They are all members of the EURO Working Group on MCDA.

Software

iMOLPe - A computational tool for teaching and decision support in multi-objective linear programming

Carlos Henggeler Antunes and Maria João Alves

University of Coimbra / INESCC Coimbra, Portugal
ch@deec.uc.pt; mjalves@fe.uc.pt

Teaching optimization algorithms to engineering and economics & management students requires, besides the exposition to the essential concepts and methods, a hands-on approach by means of computational tools that enable students to experiment and exert their critical thinking on the results. This is particularly important in teaching multi-objective optimization since a “paradigm change” occurs in the sense that an optimal solution “vanishes” and the non-dominated solution set needs to be discovered, hopefully in a constructive manner that may shed light on the nature of the trade-offs involved.

Presenting a decision maker (DM) with a large set of non-dominated solutions does not generally convey usable information for actual decision support purposes. Therefore, the involvement of the DM by providing indications about his/her preferences is of outmost importance to guide and reduce the scope of the search process, thus minimizing both the computational effort required for computing new solutions and guaranteeing that these solutions are more in accordance with his/her (evolving) preferences. This is accomplished in the operational framework of interactive methods, which intertwine computation steps and judgment steps thus allowing for a progressive shaping of the DM’s preferences as the selective characterization of the non-dominated solution set unfolds.

In this setting, the integration of different interactive procedures of multi-objective linear programming (MOLP), using different solution computation techniques, search strategies, preference elicitation requirements, visual interaction mechanisms and result displays, is the most adequate tool to be offered to students approaching these topics for the first time (after having been exposed to, at least, single objective linear optimization). Our experience shows that this is the best entrance door for enhancing the students' understanding of the main issues at stake in multi-objective optimization, before progressing to more technically demanding topics as integer and non-linear optimization or approximate methods as meta-heuristics.

We have developed a computational tool for teaching purposes and decision support in MOLP problems. The aim is to offer students in engineering and economics & management an intuitive environment, in which the main theoretical and methodological concepts of multi-objective optimization can be apprehended through experimentation, thus learning at their own pace. This tool can also be used by academics and practitioners as a basis for experimentation and decision support in MOLP models, enabling to compute non-dominated solutions using different strategies and providing different result displays that interconnect the information that is being gathered.

This software, called Interactive MOLP Explorer – iMOLPe, has been developed for Windows. It mainly includes:

- different scalarizing techniques for computing non-dominated solutions, namely the weighted-sum, e-constraint and reference point techniques, which can be used individually or combined (for instance, by optimizing a weighted-sum considering additional constraints on the objective function values);
- solution search strategies and visualization of results originally implemented within the TRIMAP method (Clímaco and Antunes, 1987, 1989), such as the graphical display of indifference regions on the weight space (parametric diagram for the weighted-sum scalarization), available for problems with two or three objective functions; the graphical translation of bounds specified for the objective function values onto the weight space; the graphical display of the 2D or 3D objective function space, showing the non-dominated extreme points (vertices) already computed and the non-dominated edges connecting adjacent non-dominated vertices;
- the Step Method - STEM (Benayoun et al., 1971), the Interval Criterion Weights - ICW (Steuer, 1977, 1986) and the Pareto Race (Korhonen and Wallenius, 1988) interactive methods;
- an exact procedure to compute the nadir point (Alves and Costa, 2009).

Although the software is intended to be mainly used as an interactive explorer, it further includes a vector-maximum algorithm (Steuer, 1986) that computes all efficient extreme points to the MOLP problem. This algorithm can also be used within the ICW interactive method, after the contraction of the criterion cone, to compute a subset of all efficient extreme points (the solutions that are attainable with the reduced criterion cone).

A limited version of the software (with maximum problem dimensions restricted to 6 objective functions, 100 decision variables and 100 functional constraints) is available for download from: http://www.uc.pt/en/org/inescc/products. The package includes a help file and a folder with problem examples.

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About the 78th Meeting

On the 24, 25 and 26 October 2013, the 78th Meeting of the European Working Group on Multiple Criteria Decision Aiding was held at the Department of Economics and Business of the University of Catania (Italy).
About 50 researchers participated to the meeting that had as main theme "Multicriteria decision aiding in finance" and was scheduled in six different sessions. A round table on ''Multicriteria decision aiding and financial risk evaluation" was organized on the first day. The participants to the round table were Bernard Roy, Roman Słowiński, Jaap Spronk and Constantin Zopounidis.
During those days were also presented the 79th edition of the meeting to be held in Athens in Spring 2014 and in Quebec, Fall 2014.
On Saturday, 26 October, 2013, the participants visited the Greek theatre of Syracuse and did a tour of the city.
Note that during the meeting the sun has been always shining and the weather has been pleasantly hot.

Last but not least, on early Saturday morning Mount Etna erupted above the town of Catania, spewing lava and sending a plume of ash into the air ….

SCIENTIFIC PROGRAM / PROGRAMME SCIENTIFIQUE
Jeudi 24 octobre 2013 / Thursday 24th October 2013

12h30 – 13h30 / 12:30pm – 1:30pm : Accueil des participants et inscriptions / Welcome and registration of participants

13h30 – 14h00 / 1:30pm – 2:00pm : Bienvenue à Catania / Welcome to Catania (Salvatore Greco - Benedetto Matarazzo)

14h00 – 16h00 / 2:00pm – 4:00pm : 1ère session / 1st session
- Bernard Roy, José Rui Figueira, J. Almeida-Dias, Discriminating thresholds as a tool to cope with imperfect knowledge in multiple criteria decision aiding: Theoretical results and practical issues
- Tuomas J. Lahtinen, Raimo P. Hämäläinen, Path dependency in the Even Swaps Method
- Tommi Tervonen, Gert van Valkenhoef, Entropy-optimal weight constraint elicitation with additive multi-attribute utility models
- Yannis Siskos, Kostas Mastorakis, Eleftherios Siskos, Multicriteria decision and Argumentation : Application to The process of evaluating environmental projects
Travaux soumis à discussion / Paper submitted to discussion :
- Fouad Ben Abdelaziz, Hatem Masri, Houda Alaya, A Stochastic Goal Programming Approach for the Multiobjective Stochastic Vehicle Routing Problem
- Alain Broutin, Vers une approche multicritère du jeu d'entreprise "Forest"
- E. Grigoroudis, Y. Politis, Evaluating extensions of the MUSA method for modeling additional preferences
- Silvia Angilella, Sebastiano Mazzù, The Financing of Innovative SMEs: a multicriteria credit rating model

16h00 – 16h15 / 4:00pm – 4:15pm : Pause café / Coffee break

16h15 – 18h15 / 4:15pm – 6:15pm : 2ème session / 2nd session :
Round table: L'aide multicritère à la décision et à l'évaluation des risques en finance / Multiple Criteria Decision Aiding and financial risk evaluations
(Bernard Roy, Roman Słowiński, Jaap Spronk, Constantin Zopounidis)

Vendredi 25 octobre 2013 / Friday 12th Ocotober 2013
9h00 – 10h30 / 9:00am – 10:30am : 3ème session / 3rd session :
- Marta Bottero, Valentina Ferretti, José Rui Figueira, Salvatore Greco, Bernard Roy, An extension of Electre III for dealing with a multiple criteria environmental problem with interaction effects between criteria (40 minutes)

- Ky Vu, Horst Hamacher, Improved box representation of Pareto sets and application to bicriteria multicommodity network flows

Travaux soumis à discussion / Papers submitted to discussion :
- Panagiotis Manolitzas, Evangelos Grigoroudis, Nikolaos Matsatsinis, MEDUTA II: Integrating Simulation techniques and Stochastic UTA for the improvement of an Emergency Department
- Luisa Sturiale, Maria Rosa Trovato, The DRSA as tool for the social evaluation of the protection and the enhancement environmental policies
- Antonio Boggia, Gianluca Massei, Measuring sustainability using a GIS-multicriteria model

10h30 – 10h45 / 10:30am – 10:45am : Pause café / Coffee break

10h45 – 12h45 / 10:45am – 12:45am : 4ème session / 4th session :

- Yves De Smet, A summary of recent researches about the PROMETHEE methods
- Risto Lahdelma, Ian Durbach, Pekka Salminen, AHP and Stochastic Multicriteria Acceptability Analysis
- Olivier Cailloux, Marc Pirlot, Descriptive models of rational preferences
- Jasmin Tremblay, Irène Abi-Zeid, Multicriteria decision and Argumentation : Application to the process of evaluating environmental projects

Travaux soumis à discussion / Papers submitted to discussion :
- Zoe Nivolianitou, A GIS-based Decision Support System for Land Use Planning
- Vasile Postolică, Dual Isac's Cones
- Chiara D'Alpaos, Canesi R.1, Oppio A.2, MCDA approaches in Real Estate Investment Decisions: A Multidimensional Framework for Risk Assessment
- Salvatore Corrente, Salvatore Greco, Milosz Kadziński, Roman Słowiński, Ordinal Regression and Robust Ordinal Regression for non-monotonic value functions

12h45 – 14h15 / 12:45am – 2:15pm : Lunch

14h15 – 15h00 / 2 :15pm – 3:00pm : Vie du groupe de travail et prochaines réunions / Group next meetings,
Zoe Nivolianitou, Athens meeting, spring 2014; Irène Abi-Zeid, Québec meeting, Autumn 2014.

15h00 – 16h30 / 3:00pm – 4:30pm : 5ème session / 5th session :

- Fabio Fantozzi, Fabio Spizzichino. On stochastic dependence among targets components in the Target-Based Approach to Utility Functions
- Miłosz Kadziński, Salvatore Corrente, Salvatore Greco, Roman Słowiński, Preferential reducts and constructs in robust multiple criteria ranking and sorting
- Maria A. de Vicente, Jaime Manera, Vincent Clivillé, Lionel Valet, Parameter setting support for a 3D images processing systems
Travaux soumis à discussion / Papers submitted to discussion :
- Bastien Rizzon, Vincent Clivillé, Sylvie Galichet, Aide à la décision pour les entreprises industrielles inscrites dans une démarche de développement durable
- Georgios Samaras, Maria Giannoula, A Multicriteria Approach for Selecting a Landfill Location
- Mauro Munerato, modeFRONTIER : the new MCDM tool
- Salvatore Corrente, Salvatore Greco, Milosz Kadziński, Roman Słowiński, Inducing probability distributions on the set of value functions

16h30 – 16h45 / 4:30pm – 4:45pm : Pause café / Coffee break

16h45 – 18h15 / 16:45pm – 18:45pm : 6ème session / 6th session :
- Adiel Almeida-Filho, An application of a MCDA model in a supplier selection problem
- Alfio Giarlotta, The pseudo-transitivity of preference relations: strict and weak (m, n)-Ferrers properties
- Sarah Ben Amor, Kaouthar Lajili ,Exploring the risk tolerance in the gold industry: A multicriteria approach
- Willem K. M. Brauers, Romualdas Ginevicius, Selection of shares for a shareholder by Multiple Objectives Optimization

Travaux soumis à discussion / Papers submitted to discussion :
- Vassilios Christopoulos, Claudia Ceppi, Francesco Mancici, Coastal vulnerability to climate change: a coupled scenario analysis with multicriteria method: the case of metropolitan area of Bari (Italy)
- Alfio Giarlotta, A genesis of interval orders and semiorders: transitive NaP-preferences
- Maria Franca Norese, Giuliano Dall'O', Annalisa Galante, Chiara Novello, A Multicriteria Decision Aiding Methodology to support Public Administration on Sustainable Energy Action Plans
- Salvatore Corrente, Michael Doumpos, Salvatore Greco, Roman Słowiński, Constantin Zopounidis, Applying Multiple Criteria Hierarchy Process to UTADIS and UTADISGMS

20h30 / 8:30pm : Dîner de gala à Catania / Dinner in Catania

Saturday 26th October 2013

- Excursions / Social activities

Forthcoming meetings

6-8/1/2014
ISAIM 2014 - 13th International Symposium on Artificial Intelligence and Mathematics
Fort Lauderdale, Florida
http://www.cs.uic.edu/Isaim2014/

8/1/2014
SOPS 2014 - NSF Workshop on Self-Organizing Particle Systems
Portland, Oregon, USA
http://sops2014.cs.upb.de/

12-17/1/2014
2nd International Optimisation Summer School
Kioloa Beach, New South Wales, Australia
http://optimisationmelbourne.wordpress.com/2013/09/07/summer-school/

5-9/2/2014
EURO mini-conference on Optimization in the Natural Sciences
Aveiro, Portugal
http://minieuro2014.web.ua.pt/

16-21/2/2014
LION 8: Intelligent optimization in Bioinformatics, Biomedicine and Neuroscience
Gainesville, Florida, USA
http://caopt.com/LION8/index.php

17-28/2/2014
EURO PhD SCHOOL on MCDM - MULTRICRITERIA DECISION MAKING WITH MATHEMATICAL PROGRAMMING
Madrid, Spain
http://www.mat.ucm.es/imeio/cursos/EPS_MCDM

28/2-4/3/2014
6th German Polish Conference on Optimization Methods and Applications
Wittenberg, Germany
http://www.gpco2014.de/

2-4/3/2014
INFORMS Telecommunications 2014
Lisbon, Portugal
http://www.informstelecom2014.fc.ul.pt

5-7/3/2014
ISCO 2014 - 3rd International Symposium on Combinatorial Optimization
Lisbon, Portugal
http://ISCO2014.fc.ul.pt

6-8/3/2014
3rd International Conference on Operations Research and Enterprise Systems
Angers, Loire Valley, France
http://www.icores.org

19-21/3/2014
11th ESICUP Meeting
Beijing, China
http://www.fe.up.pt/~esicup/extern/esicup-11thMeeting

30/3-2/4/2014
14th International Conference on Project Management and Scheduling
Munich, Germany
http://www.pms2014.wi.tum.de/

30/3-1/4/2014
2014 INFORMS Conference on Business Analytics and Operations Research
Boston, MA, USA
http://meetings.informs.org/analytics2014/

1-2/4/2014
7th Simulation Workshop (SW14)
Worcestershire, UK
http://www.theorsociety.com/SW14/

9-11/4/2014
APMOD 2014 - 11th International Conference on Applied Mathematical Optimization and Modelling
Coventry, U.K.
http://www.apmod2014.org/

14-16/4/2014
Statistical and Probabilistic Methodologies for Energy Systems - CRISM Workshop
Warwick, U.K.
http://www.warwick.ac.uk/CRISM

Spring, 2014
79th EWG on MCDA
Athens, Greece

14-17/4/2014
DEA2014 - 12th International Conference on Data Envelopment Analysis
Kuala Lumpur, Malaysia
http://deaconference.com/dea2014

23-25/4/2014
EvoSTOC 2014 - (Evolutionary Algorithms / Metaheuristics in Stochastic and Dynamic Environments)
Granada, Spain
http://www.evostar.org/cfpEvoSTOC.html

23-25/4/2014
EvoCOP 2014 - 14th European Conference on Evolutionary Computation in Combinatorial Optimisation
Granada, Spain
http://www.evostar.org/

1-3/5/2014
ECCO XXVII - CO 2014 Joint Conference
Munich, Germany

http://www.ecco2014.ma.tum.de/

9-10/5/2014
Symposium on Discrete Mathematics 2014
Frankfurt, Germany
http://www.math.uni-frankfurt.de/dm2014/

19-22/5/2014
SIAM Conference on Optimization (OP14)
San Diego, California, USA
http://www.siam.org/meetings/op14/

19-23/5/2014
NIDISC'14 - 17th International Workshop on Nature Inspired Distributed Computing
Phoenix, Arizona, USA
http://nidisc2014.gforge.uni.lu/

19-23/5/2014
CPAIOR 2014 - Eleventh International Conference on Integration of Artificial Intelligence and Operations Research Techniques in Constraint Programming
Cork, Ireland
http://4c.ucc.ie/cpaior2014/

27-30/5/2014
ECMS 2014 - 28th European Conference on Modelling and Simulation
Brescia, Italy
http://www.scs-europe.net/conf/ecms2014/index.html

29-31/5/2014
Computational Management Science 2014 - CMS2014
University of Lisbon, Portugal
http://cms2014.fc.ul.pt

4-6/6/2014
OPTI 2014 - Engineering and Applied Sciences Optimization
Kos Island, Greece
http://www.opti2014.org

5-7/6/2014
International IEEE Conference Logistics Operations Management, GOL'14
Rabat, Morocco
http://www.ensias.ma/gol/

10-13/6/2014
GDN2014
Toulouse, France
http://www.irit.fr/gdn2014/

11-20/6/2014
EURO Summer Winter Institute "Operational Research applied to health in a modern world"
Forte di Bard, Italy
http://orahs.di.unito.it/eswi.html

16-18/6/2014
INFORMS Decision Analysis Society Conference 2014
Georgetown University, USA
https://www.informs.org/Community/DAS/DAS-Conference

16-20/6/2014
ISOLDE 2014 - International Symposium On Locational DEcision
Naples and Capri, Italy
http://www.isolde2014.org

23-25/6/2014
XVII - 17th Conference on Integer Programming and Combinatorial Optimization
Bonn, Germany
http://www.or.uni-bonn.de/ipco/

26-28/6/2014
EURO Working Group conference on Operational Research in Computational Biology, Bioinformatics and Medicine
Poznan, Poland
http://cbbm2014.cs.put.poznan.pl

7-10/7/2014
PMAPS 2014 - International Conference on Probabilistic Methods Applied to Power Systems
Durham, UK
http://www.dur.ac.uk/pmaps.2014

IFORS 2014 - 20th Conference of the International Federation of Operational Research Societies
Barcelona, Spain
http://www.ifors2014.org

19/7/2014-1/8/2015
EURO Summer Institute 2014. OR in Agriculture and Agrifood Industry
Lleida, Spain
http://orafm.udl.cat/?page_id=233

20-25/7/2014
WCCM 2014 - 11th World Congress on Computational Mechanics
Barcelona, Spain
http://www.wccm-eccm-ecfd2014.org

20-25/7/2014
ORAHS 2014 - Operational Research Applied to Health Services
Lisbon, Portugal
http://www.orahs2014.fc.ul.pt

28-30/7/2014
Optimization 2014
Guimarães, Portugal
http://optimization2014.dps.uminho.pt

29-31/7/2014
6th International Conference on Applied Operational Research - ICAOR 2014
Vancouver, Canada

http://www.tadbir.ca

24-29/8/2014
19th IFAC World Congress IFAC 2014
Cape Town, South Africa
http://www.ifac2014.org/

26-29/8/2014
PATAT 2014 - 10th International Conference on the Practice and Theory of Automated Timetabling
York, United Kingdom
http://www.patatconference.org/patat2014/

2-5/9/2014
International Conference on Operations Research, OR2014
Aachen, Germany
http://www.or2014.de

8-11/9/2014
EngOpt 2014 - 4th International Conference on Engineering Optimization
Lisbon, Portugal
http://www.dem.ist.utl.pt/engopt2014

10-12/9/2014
ANTS 2014 - Ninth International Conference on Swarm Intelligence
Brussels, Belgium
http://iridia.ulb.ac.be/ants2014

24-26/9/2014
The 15th International Conference on Operational Research KOI 2014
Osijek, Croatia
http://www.hdoi.hr/en/call-for-papers

Autumn 2014
80th EWG on MCDA
Québec (Canada)

27-31/10/2014
META'2014 - International Conference on Metaheuristics and Nature Inspired Computing
Marrakech, Morocco
http://meta2014.sciencesconf.org/

9-12/11/2014
INFORMS Annual Meeting 2014
San Francisco, USA
http://meetings2.informs.org/sanfrancisco2014/

3-7/8/2015
23rd International Conference on Multiple Criteria Decision Making MCDM 2015
Hamburg, Germany
http://www2.hsu-hh.de/logistik/MCDM-2015/

INFORMS Annual Meeting 2013 Minneapolis
October 6-9, 2013
Minneapolis Convention Center & Hilton Minneapolis, USA
http://www.informs.org

The 36th Annual Meeting of the Society for Medical Decision Making
October 19-24, 2014
Doral Golf Resort and Spa, USA
http://smdm.org/smdm_annual_meetings.shtml

INFORMS Annual Meeting 2014 San Francisco
November 16-19, 2014
Hilton San Francisco, USA
http://www.informs.org

Announcements and Call for Papers

Multiple Criteria Decision Analysis on Financial Lexicon, Constantin ZOPOUNIDIS

http://lexicon.ft.com/Term?term=multiple-criteria-decision-analysis

Public Decision Making and Decision Conferencing (PLENARY SPEAKER Carlos Bana, 22nd International Conference on Multiple Criteria Decision Making, Malaga, 2013)

http://web.ist.utl.pt/carlosbana/Plenary%20Carlos%20Bana%20e%20Costa%20MCDM%202013%20Malaga%2020_6_13.pdf

Web site for Annoucements and Call for Papers:
www.cs.put.poznan.pl/ewgmcda

Call for Papers
Call for paper : Euro Journal of Decision Processes / Special issue on Preference Elicitation and Learning

Marc Pirlot and Vincent Mousseau are editing a feature issue on preference elicitation and learning (see the appended Call for Papers.
Deadline for the paper, the end of November.
See for more information
http://link.springer.com/journal/40070/1/1/page/1

IFORS 2014. Barcelona, Spain, July 13-18 2014

Abstract submissions opens: 1 November 2013
Abstract submissions closes: 31 January 2014

Early Registration: 1 November 2013- 28 February 2014
Regular Registration: 1 March - 30 April 2014
Late and on-site registration:1 May - 13 July 2014

The IFORS 2014 Triennial Conference will be held in Barcelona, Spain,
July 13-18 2014.

Contacts:
Elena Fernández. Organizing Committee Chair Stefan Nickel. Program Committee Chair
All attendees, including speakers and session chairs, must register and pay the registration fee. If you need an early confirmation for visa or budgetary reasons, please contactinfo@ifors2014.org <mailto:info@ifors2014.org>. For all other aspects, please contact the conference secretariatifors2014@pacifico-meetings.com
http://www.ifors2014.org

Books

Multi-criteria Decision Analysis: Methods and Software
By Ishizaka Alessio, Nemery Philippe, Multicriteria Decision Aid: Methods and software, Wiley, Chichester, 2013 (ISBN: 978-1-1199-7407-9)

http://eu.wiley.com/WileyCDA/WileyTitle/productCd-1119974070.html
It describes the leading MCDA techniques: AHP, AHPSort, GAHP, ANP, MAUT, UTA, UTA GMS, GRIP, MACBETH, PROMETHEE I, PROMETHEE II, PROMETHEE GDSS, FLOWSORT, GAIA, FS-GAIA, ELECTRE III, ELECTRE-TRI, TOPSIS, GOAL PROGRAMMIG, WEIGHTED GOAL PROGRAMMIG, LEXOGRAPHIC GOAL PROGRAMMIG, CHEBYSHEV GOAL PROGRAMMIG, DEA, DECISION DECK AND DECERNS.

Multi-Criteria Decision Analysis: Environmental Applications and Case Studies**,** published in 2012 by CRC Press.
P. Vasant, N. Barsoum and Jeffrey Webb , Innovation in Power, Control, and Optimization: Emerging Energy Technologies
http://www.igi-global.com/book/innovation-power-control-optimization/52721
Through a collection of case studies, **Multi-Criteria Decision Analysis: Environmental Applications and Case Studies** gives readers the tools to apply cutting-edge MCDA methods to their own environmental projects. It offers an overview of the types of MCDA available and a conceptual framework of how it is applied, with the focus on its applicability for environmental science.

Articles Harvest

(This section is prepared by Salvatore CORRENTE, salvatore.corrente@unict.it)
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Announcement:

If you would like to become member of the Group please contact Rui Figueira (figueira@tecnico.ulisboa.pt) or Miłosz Kadziński (milosz.kadzinski@cs.put.poznan.pl)

A World Wide Web site for the EURO Working Group on "Multicriteria Aid for Decisions" is available at the URL:

http://www.cs.put.poznan.pl/ewgmcda/

Web site Editor: Miłosz Kadziński

This WWW site is aimed not just at making available the most relevant information contained in the Newsletter sections, but it also intends to become an online discussion forum, where other information and opinion articles could appear in order to create a more lively atmosphere within the group.