Book Review

Why Wind Energy?

Ivan Popchev

Bulgarian Academy of Sciences
E-mail: ivan.popchev@iict.bas.bg

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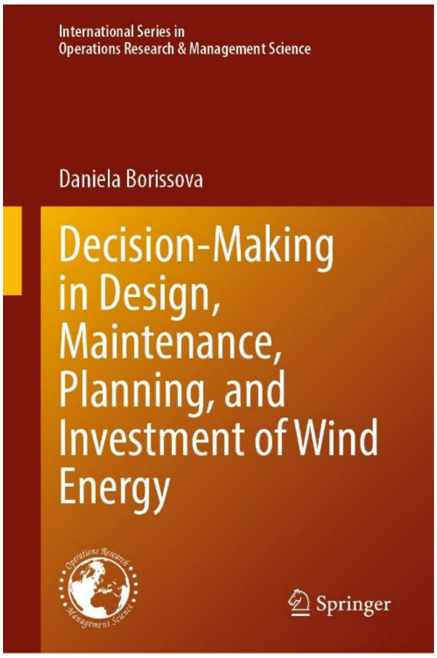

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"The main objective of the book is to show how decision models can be applied to solve specific problems related to wind energy. The book begins with a description of the mathematical apparatus needed to formulate mathematical models and the problem-solving methods that support decision-making. The content of the book sequentially goes through all stages of wind farm construction, starting from site selection and wind power plant layout design, through some turbine manufacturing processes and decision-making in structural health monitoring and predictive maintenance of wind turbines, to some economic and social aspects related to the evaluation of indicators when investing in wind energy, types of risks associated with wind energy projects, and the determination of energy consumption balance index, including the determination of the index of the relative share of wind energy consumption among the other renewable sources" [1].

In the wind energy sector, significant funds continue to be invested in the construction of wind power plants, and therefore it is important to use mathematical models to determine well-motivated investment decisions. Wind energy plays an essential role in national, and world economics. All of this means that appropriate decision-making models are needed to support management in making decisions related to: 1) wind site evaluation and selection; 2) the planning and design of wind farms; 3) putting into operation: actual construction and inclusion in the transmission network; 4) implementation, operation and maintenance activities of wind turbines and last but not least; 5) some economic aspects and social impact of wind energy. In this regard, the published book offers a comprehensive study of these basic problems, for which models are proposed for making informed decisions.

Chapter 1 deals with general approaches to decision-making. It presents a diagram of the decision-making process. A classification of decision support systems types is described too. The multiple attribute decision-making techniques are presented and difference between multiple attribute and multi-objective problems are described. Due to the diversity of real-world problems, aggregation of fuzzy relations and functions could be useful [2-4]. Special attention is given to the formulation of optimization models and methods of their solving. Some specifics of combinatorial optimization and decision-making in engineering design are described too. It is worth to mention that all chapters of the book contain comprehensive references.

Chapter 2 examines the life cycle of a wind farm, which is presented as an iterative process passing successively through 5 main stages as shown in Fig. 1.

Fig. 1 Life cycle of a wind farm

To solve the site assessment problems, a multi-attribute decision-making model is proposed for wind site location selection by considering groups of evaluation indicators. These indicators relate to technical, economic, and environmental aspects and are considered simultaneously in formulating a combinatorial mathematical model for choosing the best place to build a wind power plant.

The second stage refers to planning and design of wind farm. Based on an analysis of the available onshore and offshore wind installations, potential countries where to start building a new wind farm can be better considered. In the presence of more than one potential country, these indicators are used in the proposed multicriteria combinatorial optimization model for economies ranking with investment purposes in wind energy [5].

The availability of a wind energy project and an investment country are prerequisites for the planning step, which is related to determining the right seller (supplier) of suitable wind turbines. For this purpose, the author proposes a group decision-making model for supplier selection. Furthermore, a generalized approach is proposed to support business decisions involving different strategies related to determining the most preferred alternative, determining several good alternatives simultaneously, or ranking all given alternatives [6]. Each strategy is based on a formulated optimization model.

Last but not least in the implementation of a wind power plant project are the activities related to hiring personnel. As in modern society, qualified personnel are of great importance, the monograph discussed a group decision-making model for personnel ranking taking into account the candidates' hard and soft skills and the expertise of group members [7]. Besides this, it is also proposed a model-driven framework for assessment of personnel skills by generating a variety of online and print tests with different degrees of complexity [8].

The third stage refers to construction and commissioning and the activities concern logistics, civil engineering, foundation, turbine installation, sea-based support, marine coordination, weather forecasting and metocean data, electricity network, offshore/onshore substation, connection to the grid, etc.

The fourth stage is focused on operation and maintenance activities up to 25 years of a standard lifetime or 50 years of the same wind farm subjected to modernization. This stage includes the routine servicing and repairs that are required to achieve the designed lifetime of the wind turbine and to ensure compliance with financial, safety, security, and leasing agreements, training, health, and safety inspections, turbine maintenance, and service.

The fifth stage refers to the end of wind power plant life that has reached its service life can generally choose four treatment methods, including full decommissioning, constant repowering, repowering preceded by full decommissioning, and transition towards a tourist attraction [9].

Chapter 3 deals with problems of decision-making in wind farm design starting with a concept for wind farm layout design. Wind farm layout has become increasingly important in recent decades due to not only the promotion of wind energy development but due to the differences in different geographical locations and conditions as shown in Fig. 2.

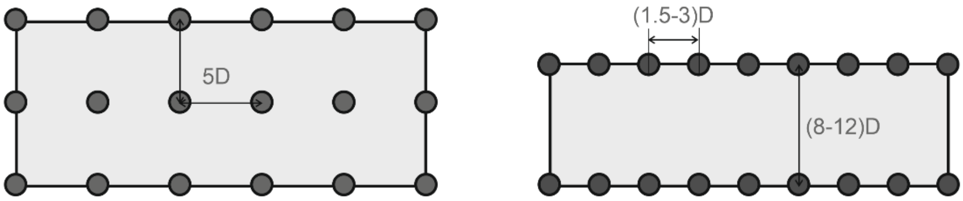

Fig. 2 Wind turbines placement: a) uniform wind direction; and b) predominant wind direction.

To cope with such types of problems, various models applicable to the layout design of wind farms with different specific characteristics are proposed. By optimizing the micro-layout of the wind turbines, a good balance is possible to achieve between the energy output and the costs of building a wind farm. Each position of the turbines must be consistent with the available wind resource, respectively with the distances between neighbouring wind turbines, and last but not least with the technical characteristics of the turbine itself. This requires optimizing the wind farm layout design in such a way as to achieve maximum energy production according to the exact parameters of the selected wind turbine. The distinguishing feature of the formulated optimization problems is their combinatorial nature.

A two-step algorithm is also proposed to determine the layout design of a wind farm. The first stage determines a set of possible design alternatives conforming to different design scenarios by multi-objective combinatorial optimization while the second one aims to select the best alternative by group decision-making model [10]. In addition, an integrated framework for wind farm design is proposed that relies on the effective integration of multi-attribute decision-making/multi-attribute group decision-making models and mathematical modelling based on single or multi-objective optimization [11]. This framework contributes to the selection and evaluation of the effectiveness of the selected wind turbine in designing the wind farm layout. Two wind farm layout design models considering the presence of forbidden zones with regular and irregular geometric shapes are proposed [12, 13].

The third stage of the wind farm life cycle is related to the actual construction and inclusion in the transmission network. The challenging problem is the connection of this power plant with the electrical grid in a such way as to minimize the distance between the wind farm and the grid thus decreasing the transmission costs. To solve this problem, a model for optimizing the location of wind turbines, taking into account the location of the common connection point, is presented.

Another promising direction related to wind energy is the construction of hybrid wind-solar power plants due to the nature of these two types of renewable energy. The process of selection of hybrid wind-solar power plants is presented starting with the determination of climatically acceptable sites, after which these sites are evaluated according to their specific technical parameters; followed by the relevant economic assessment; the next assessment is against the environmental criteria and finally, the assessment is about the socio-political acceptance criteria. All these criteria related to climatic, technical, economic, ecological; and social/political are integrated into a proposed model for assessing the potential of the site for construction of a hybrid wind-solar power plant.

Chapter 4 refers to decision-making in one-dimensional cutting of blanks and processing planning. The chapter starts with description of wind turbines life cycle composed of 6 clear stages as shown in Fig. 3.

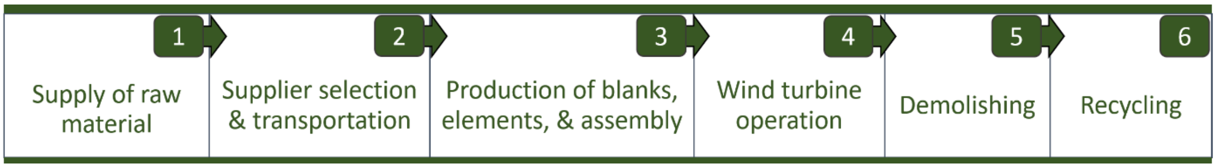

Fig. 3 Wind turbines life cycle

The proposed one-dimensional cutting stock problem applies to the construction and commissioning stage. This model allows determining the optimal length of blanks and optimal cutting patterns minimizing the waste, according to the given demands of elements [14]. By increasing the standard length, the number of blanks can be reduced required to fulfil the requested order can be reduced, thereby reducing waste and costs.

After the blanks are cut to the specified length, some sequence of operations to obtain the particular element for the wind turbine module. An optimization model for planning a multi-machine shop based on multiple task solving with different sequences of detail processing is proposed. The minimum makespan determines the optimal job shop schedule. The availability of many identical problems corresponding to different scenarios is overcome by using a parallel algorithm.

The next step when the machined parts are present is the assembly of the corresponding modules. The design process as an iterative one often involves testing new ideas and new element concepts and using modular products with a shared common platform and various additional modules is considered as promising. A group decision-making model was proposed to design a product configuration, where experts evaluate each item in terms of its characteristics, considering the set goal [15].

Another important problem at this stage is personnel scheduling. Personnel scheduling is usually non-trivial due to the many sources of variability inherent in real service systems [16]. Optimizing staffing does not mean reducing the number of staff, but finding the right number of employees at the right time in the right place. This can be done by using different criteria or strategies for: 1) the determination of minimum staff idles; 2) the determination of minimum processing time; or 3) the simultaneous determination of minimum staff idles and minimum staff number [17].

Chapter 5 concerns the decision-making in structural health monitoring and predictive maintenance of wind turbines that refers to the fourth stage of the wind farm life cycle: operation and maintenance. Many condition-monitoring techniques are applied to monitor and inspect the components in a wind turbine. One of the most important is the vibration analysis of different components such as the nacelle, tower, blade, bearings, shaft, gearbox, and generator [18]. In this regard, determining an optimal number of sensors and their locations for structural health monitoring is of great importance. Combinatorial optimization models are proposed to determine the optimal number and placement of the sensors by dropping out the sensors with the smallest information accuracy loss [19].

Another problem related to wind turbines' operation is related to predictive maintenance for which mathematical models for the determination of optimal maintenance strategy (replace or repair) are presented. The first one refers to the maintenance of the machine as a whole, while the second model refers to the determination of the maintenance strategy of each component. Such models, along with the data collected by the sensors, can be used to assess the condition of the machine and predict upcoming failures that can be integrated with an intelligent e-maintenance decision-support system [20]. The degradation of engineering systems over time is associated with significant uncertainty, and therefore the proposed mathematical models for group decision-making accounting for this uncertainty through the Wald, Laplace, Hurwitz or Savage criteria may be a suitable solution.

Chapter 6 refers to the economic aspects and social impact of wind energy. Some indicators useful in evaluating the feasibility of wind energy project investments from various perspectives related to net present value, running costs, payback period, return on investment, cost-benefit analysis levelized cost of wind power are discussed. A special section is provided for the assessment of job creation and the quality of working conditions. The transition to alternative energy sources continues to be a topic of extreme importance as wind energy investments receive a lot of attention and it is necessary to consider the complex combination of the main groups of risks shown in Fig. 4.

Fig. 4 Groups of risks associated with wind energy projects

The chapter ends with an energy balance index formed by different energy sources that can be used to evaluate the transition to a low-carbon economy.

The monograph presents an extensive survey of wind energy and related decision-support models. All models described are illustrated with appropriate numerical examples and each chapter is well supported with relevant references.

Instead of a conclusion

Why wind energy? Wind energy today and in the future is a necessity not only for each of us but also for the future of the global transition to clean energy as an active participant in the climate war.

The Springer Publisher should be congratulated with the publication of this very useful and informative book which is the first one devoted entirely to wind energy.

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