

ABSTRACT

The main challenge of the dissertation was to identify a Day-Ahead Market system to enable the development of a model of it that can efficiently and at the same time effectively support the decision-making processes involved in managing this market. The Day-Ahead Market system is a management system that, in the category of systems engineering, can be a system with multiple input streams and multiple output streams. It has as input the streams of the volume of electricity delivered and sold, and as output, the stream of the volume-weighted average price of electricity delivered and sold. This represents one of the key challenges in modelling and managing the Day-Ahead Market. Furthermore, this becomes particularly important in the context of the challenges of developing and managing the Electricity Market and the Polish Power Exchange and its subsystems.

The in-depth literature study carried out has shown that there is a lack of binding research results in existing scientific studies on the identification and modeling of this type of system, leading to metamodels in general and Day-Ahead Market metamodels in particular. Therefore, it can be concluded that there is a specific research gap due to the discrepancy between the need for models and metamodels of the Day-Ahead Market system and the existing theoretical and implementation possibilities of creating such models and metamodels by means of methods of control theory and management systems engineering, including methods of identification and meta-identification of management systems.

The basic research problem solved in the dissertation is to carry out identification modelling and meta-identification modelling, on the grounds of systems theory and engineering, including the use of management systems engineering in particular, in terms of capturing the Day-Ahead Market system of the Polish Power Exchange as a management system.

An additional research problem, the solution of which is presented in the dissertation, arises from the lack of a clear assessment of the quality of the obtained system models. Therefore, a new criterion was developed for assessing the quality of system models, including the quality of the Day-Ahead Market system models, which was called solidity combining the efficiency and effectiveness of the system model in a kind of equilibrium.

The concept presented in the dissertation for solving the research problems posed in this way assumes that the identification results in a Day-Ahead Market system model in terms of systems engineering, as a management system model. Furthermore, an original approach to the meta-identification of the Day-Ahead Market system carried out using a set of models obtained as a result of rolling identification is also proposed. The parameters and models determined using

this approach allowed the development of a metamodel of the Day-Ahead Market system resulting from this meta-identification of the Day-Ahead Market system.

The identified research problems are related to the need to obtain models and metamodels of the Day-Ahead Market system, which leads to the definition of the general objective of the thesis in systemic terms in the form of a process of identification and meta-identification of the Day-Ahead Market system functioning as a management system at Polish Power Exchange SA.

Associated with the aforementioned objective of the dissertation are the following specific objectives:

- 1) the location of the Day-Ahead Market system in terms of systems engineering and management and quality sciences against the background of research issues concerning the Electricity Market system,
- 2) review of identification modelling methods in terms of systems engineering, including a description of the essence of identification, review of possibilities to obtain system models, review of methods used in the modelling of the Day-Ahead Market system of TGE S.A., description of identification modelling of the Day-Ahead Market system, conducting a critical review of the literature on the subject of obtaining sufficiently accurate models of the Day-Ahead Market system,
- 3) development of a methodology for identification and meta-identification studies of the Day-Ahead Market system, including a description of the stages of the research process, a systemic view of Day-Ahead Market as a management system, and its evaluation in terms of effectiveness, efficiency, and robustness,
- 4) conduct identification and generation of a catalogue of discrete and continuous parametric models of the Day-Ahead Market system and a catalogue of continuous models in state space,
- 5) carrying out meta-identification and generation of discrete and continuous parametric metamodels of the Day-Ahead Market system and continuous metamodels in the state space,
- 6) construction of simulation models, and then conducting the simulation, comparative, and sensitivity studies with their use from the point of view of the formulated model and system accuracy criteria, taking into account relative errors and Day-Ahead Market errors, as well as from the point of view of model and system efficiency and solidity and model effectiveness to the Day-Ahead Market system,

- 7) carrying out interpretation of model parameters and examination of changes in the quality of the model, including: in the scope of runs of effectiveness, efficiency, and solidification in the function of resources, which is the volume of electricity supplied and sold in the Day-Ahead Market in the examined hour of the day,
- 8) formulation of conclusions and further research directions.

The following research hypotheses were positively verified in the dissertation:

- 1) Identification carried out with the use of systems engineering, in particular with the use of identification methods, makes it possible to build models of the Day-Ahead Market system of TGE S.A. with a relatively high degree of accuracy to the real system.
- 2) The application of parametric identification methods with the use of numerical rolling data makes it possible to obtain a catalogue of models of the Day-Ahead Market system, which are a source of data for the purpose of carrying out its meta-identification process.

The qualitative and quantitative research methodology proposed in the dissertation allowed the research objectives set to be met. The main effect and, at the same time, a distinguishing feature of the use of the author's approach to identification modelling presented in the dissertation is the high quality of discrete parametric models of the Day-Ahead Market system supplemented with neural models, obtained as a result of identification carried out with the use of systems theory and engineering, and, consequently, also continuous parametric models and continuous models in the state space of the TGE S.A. Day-Ahead Market system.

The obtained models of the Day-Ahead Market system can be used as a reliable source of data in the construction of a knowledge base for meta-identification purposes, also supporting forecasting, planning, or programming of future states of the Day-Ahead Market system in the process of managing the Polish Power Exchange as a subsystem at TGE SA.