REVIEW

By prof. Dr. Eng. Georgi Mitkov Pavlov, University of transport "Todor Kableshkov"
On the dissertation submitted for the award of the educational and scientific degree "doctor"
in professional field 5.2 "Electrical engineering, electronics and automation"
under the doctoral program *"Elements and devices of automation and computing technology"*
At the Institute of Robotics, Bulgarian Academy of Sciences, section *"Robotics in energy systems"*
Author: m. eng. Desislava Ivanova Delcheva
Title of dissertation: *"Improving energy efficiency in power supply systems"*

1. Biographical and professional background

Doctoral candidate m. eng. Desislava Ivanova Delcheva completed her higher education between 2010 and 2016, obtaining Bachelor's and Master's degrees in *Electrical power engineering and electrical equipment* at the "Todor Kableshkov" University of transport. In 2024 she was admitted as a doctoral student (part-time form) at the Institute of Robotics, Bulgarian Academy of Sciences, section "Robotics in energy systems" by order №92b/18.10.2024. Her scientific supervisor is Assoc. prof. DSn. eng. Iliyan Hristov Iliev.

Between 2021 and 2024 she worked as an assistant at the University of mining and geology "St. Ivan Rilski", Sofia, and since 2024 she has been an assistant at the Institute of Robotics "St. Apostle and Evangelist Matthew", BAS.

The doctoral candidate has successfully fulfilled the requirements of her individual study plan, passed all examinations with excellent results, and actively participated in scientific forums, presenting her dissertation findings. During her doctoral studies she also participated in one research project in the field of robotics in power engineering. She has been officially granted the right to defend her dissertation by order №62/24.06.2025 of the director of the Institute of Robotics.

M. eng. Delcheva demonstrates very good computer literacy and proficiency in English. Her personal qualities, coupled with her deep knowledge in the field, have facilitated the development of this dissertation and guided its orientation toward a highly relevant and prospective research topic.

2. Relevance of the research problem in scientific and applied terms. Scope and significance of the issues and specific tasks addressed in the dissertation

The dissertation is devoted to a highly relevant topic, focused on addressing specific problems in the field of power engineering and exploring possibilities for improving the energy efficiency of diverse types of energy facilities. A thorough investigation has been carried out, including the search for new approaches, the development of adequate analytical models, and the creation of software applications for monitoring and controlling the energy parameters that determine power quality in both generation

and consumption processes. The main objective of the dissertation is to develop effective, practically applicable analytical models for minimizing power losses in power supply systems, with the potential for real implementation in industrial facilities for the study and optimization of power balance.
The complexity of modern electrical equipment and systems, as well as the specificity of their operating regimes, directly affect the quality of electrical energy, which is defined by standardized quality indicators. This highlights the necessity of creating new methods and approaches for the study and control of energy efficiency and their application in real operational environments. The author presents a critical analysis of existing analytical and technical methods for assessing power and energy losses and for evaluating power balance in industrial facilities, thereby demonstrating the need for the development of new approaches. In this regard, she identifies significant potential in the application of probabilistic–statistical methods for research and analysis.
The analytical methods and scientific approaches developed in the dissertation make it possible to conduct continuous monitoring and diagnostics of parameters influencing power quality and the proper balancing of energy flows. These capabilities enhance the quality, reliability, and efficiency of operation in the diagnosed facilities, meeting the heightened requirements of modern technology. The analytical models, software applications, and results obtained, in my opinion, have wide applicability in the fields of industry, energy, and transport. In this respect, I conclude that the dissertation possesses a high degree of relevance both scientifically and in terms of practical application.

3. Structure and content of the dissertation

The dissertation consists of 175 pages and is structured into an introduction and four chapters. Each chapter concludes with the main findings obtained during the course of the research, along with the author's claimed contributions. At the end of Chapter One, which essentially serves as a literature review on the dissertation topic, the aim and the principal tasks of the research are formulated.
The dissertation also includes a bibliography comprising 116 references, of which 41 are in Latin script and 75 in Cyrillic. At the end of the work, the author has attached a list of five publications that reflect the key aspects and results of the dissertation research.

4. Candidate's familiarity with the state of the art and critical evaluation of the literature

M. eng. Desislava Delcheva demonstrates profound knowledge of her scientific field and of the subject matter of the dissertation. The candidate provides a comprehensive examination of the different types of load profiles, the parameters by which they are defined, and the methods used for their calculation. A creative and critical review of the methods applied thus far for analyzing and evaluating the transfer of various types of power and the associated losses is presented.

Methodologies are proposed for determining load parameters and characteristics under different operating regimes of the supply system, based on a probabilistic–statistical approach, which, according to the author, is the most adequate for investigating processes in power supply systems. The principal aim is to propose a precise approach to the study of power behavior in industrial facilities under operational conditions.

The complexity of modern equipment and the operating regimes of power supply systems necessitate the use of adequate real-time monitoring and control systems. This, in turn, requires the study and application of all available technical means to achieve this objective. The dissertation as a whole combines the investigation of existing methods with the development of new original analytical approaches and formulations, as well as the creation of suitable algorithms and software tools to achieve higher quality and efficiency in the power supply of industrial facilities.

After clearly formulating the main aim and the associated tasks, the dissertation systematically progresses through all levels of development— theoretical, algorithmic, and software— with the goal of achieving maximum accuracy and effectiveness. These core tasks, including extended experimental validation of the proposed solutions, are methodically addressed in the subsequent chapters of the dissertation.

5. Adequacy of the chosen research methodology in addressing the aims and objectives of the dissertation

The answer to this question is directly related to the chosen approach, the analytical methods, and the software applications employed throughout the dissertation, all of which were applied consistently with the stated aims and objectives.

In Chapter Two, methods for determining conventional power and energy losses are examined, followed by a comparative analysis of the obtained results. On this basis, the author proposes prioritizing probabilistic–statistical approaches, which provide the most realistic outcomes. A multifactorial approach to assessing power losses has also been developed and applied to five industrial sectors. The proposed methodology has been validated in practice across various industrial facilities. The author convincingly argues that conventional power losses represent a key energy indicator that should be given priority when evaluating the energy efficiency of power supply systems, as they provide a reliable measure of optimal system performance. This chapter further presents a method for the optimal unification of cable cross-sections in low- and medium-voltage networks, with the aim of reducing power and energy losses by 7–8.5%. The studies demonstrate that the realized savings exceed the investment costs required for increasing cable sizes.

In Chapter Three, an analytical model is developed to investigate the static characteristics of loads through the application of experimental design theory. Six industrial sectors are studied at two load levels, and the influence of these conditions on power behavior is assessed. The results, presented in both tabular and graphical

form, establish the effect of load characteristics on the energy efficiency of consumers and on the power supply system as a whole.
Chapter Four explores the possibilities of reactive power compensation and its effect on conventional power losses. Analytical expressions are derived, demonstrating that under an optimal combination of influencing factors, the condition $\delta P^* < 0$ can be achieved. This ensures an energy-efficient and economically viable operating regime for power supply systems. Experimental studies were conducted on a variety of energy-intensive facilities (electrolysis units, arc and resistance furnaces, welding machines, etc.) with the aim of improving energy efficiency. Concrete recommendations are given for optimizing their operating regimes and supply methods to achieve energy savings.
In this context, the chosen research methodology, the analytical and experimental studies conducted, and the results obtained provide a comprehensive and adequate response to the central aim and objectives formulated at the end of Chapter One of the dissertation.

6. Analytical characteristics and assessment of the reliability of the material underpinning the contributions of the dissertation

The reliability of the material presented in the dissertation is high, stemming from the comprehensive manner in which the research problem was investigated and the main results were presented. The author conducts a critical analysis and identifies the key shortcomings of existing methods and algorithms for the study and monitoring of modern power engineering facilities, subsequently proposing new approaches to improve energy efficiency. On this basis, original theoretical and experimental models have been developed for the investigation, rapid analysis, and optimization of the parameters of the examined objects within the power supply system.
In this respect, the validity and credibility of the work are further confirmed by the fact that a large part of the methods and software applications proposed by the author have been tested in real facilities and have proven their functionality.

7. Scientific and applied contributions of the dissertation. Nature and significance of the contributions

The dissertation formulates two scientific and two applied contributions, all of which I confirm as valid. The candidate proposes analytical models, verified through experimental studies, for investigating and analyzing the state of energy facilities with the aim of achieving high energy efficiency. This enables real-time assessment of energy efficiency in various objects within the fields of power engineering, industry, and transport. The dissertation has been prepared at a high scientific level. The proposed analytical models have been tested in real industrial facilities and demonstrate a high degree of validity.
The applicability of the developed analytical tools for studying real objects has been proven and is highly effective. The principal contributions of the dissertation can be summarized as follows:

- demonstrating, through novel approaches, essential new aspects of existing scientific problems and theories;
- developing new classifications, research methods, and software products;
- obtaining confirmatory empirical findings.

The results represent an original contribution to both science and practice. Their potential for application is very high. I consider the presented research work and its results to be the personal achievement of the doctoral candidate. No evidence of plagiarism or unacknowledged use of the work of other authors has been found.

8. Assessment of the extent to which the dissertation and its contributions represent the personal work of the doctoral candidate

The personal contribution of the doctoral candidate is very high. The publications and conference presentations confirm that the reported contributions are her own work or completed under her decisive leadership.

9. Publications

In accordance with the procedure for obtaining the doctoral degree, the candidate has presented a total of five publications in English. All of them have been published in the proceedings of international conferences held in Bulgaria (ISSN). The publications are co-authored, with the doctoral candidate listed as second author in four of them. I consider that in these joint publications the candidate has played a leading role. The publications reflect the most substantial and significant aspects of the dissertation research.

10. Applicability of results

The analytical and experimental studies conducted, along with the results obtained, demonstrate that the proposed original theoretical approaches and models provide effective means for the investigation and analysis of all essential parameters influencing the energy efficiency of the examined facilities and of the power supply system as a whole.

I consider the dissertation to represent a comprehensive and well-developed scientific study. Its relevance stems from the fact that it provides concrete solutions to problems related to improving the quality of electrical energy, reducing power and energy losses, and compensating for reactive power. These outcomes create the conditions for secure and reliable operation of power supply systems under all operating regimes. The degree of applicability of the results achieved is high.

11. Abstract and bibliography

The abstract fully and clearly reflects the main aspects of the dissertation, allowing for an assessment of the relevance of the problems addressed, the approaches adopted for their solution, and the results obtained. The bibliography of the dissertation is up to date and adequately reflects the current state of research on the topic. My evaluation of the candidate's awareness of the relevant literature is positive.

12. Remarks and recommendations

Remarks:

- The bibliography should list titles in Cyrillic before those in Latin script.
- The candidate should increase efforts to publish in peer-reviewed journals indexed in Scopus and web of science.

Recommendations:

- Continue research in this promising area.
- Broaden the practical application of the developed analytical models.
- Consider adapting the dissertation into a teaching aid/textbook for use in higher education and industry training.

I consider the dissertation to be highly relevant, and I am convinced that the developed analytical models, software products, and the obtained results will have broad applicability in the fields of industry, transport, and energy.

Conclusion

The dissertation is a thorough, completed research study that fully meets the requirements of the Bulgarian law on the development of academic staff and its regulations in terms of scope, structure, and content.

The dissertation of m. eng. Desislava Ivanova Delcheva on the topic *"Improving energy efficiency in power supply systems"* fully satisfies the requirements for the award of the degree doctor in professional field 5.2 *"Electrical engineering, electronics and automation"*, doctoral program *"Elements and devices of automatica and computing technology"*.

I therefore recommend to the esteemed scientific jury that m. eng. Desislava Ivanova Delcheva be awarded the educational and scientific degree "doctor."

26 august 2025

Reviewer: .....

/prof. Dr. Eng. Georgi Pavlov/