R E V I E W

of a dissertation

for the award of the educational and scientific degree **"Doctor"**

Author of the dissertation:	**M.Sc. Eng. Desislava Ivanova Delcheva**
Title of the dissertation:	**Increasing Electrical Energy Efficiency in Power Supply Systems**
Field of Higher Education:	**5.2 "Electrical Engineering, Electronics and Automation"**
Scientific specialty:	*"Elements and Devices of Automation and Computer Engineering"*
Reviewer:	*Prof. Dr. Eng. Avgust Yordanov Ivanov, Institute of Robotics, Bulgarian Academy of Sciences (BAS).*

1. General Remarks

M.Sc. Eng. Desislava Delcheva was born in 1979 and completed her Bachelor's and Master's studies in Electric Power Engineering and Electrical Equipment at the Higher School of Transport "Todor Kableshkov," Sofia, in 2016. She has worked at Bulgarian State Railways, the Ministry of Interior – General Directorate "National Police," the National Service for Protection, as an Assistant at the University of Mining and Geology "St. Ivan Rilski," Sofia, and since August 2024 she has been an Assistant at the Institute of Robotics at BAS. She was enrolled in an individual doctoral programme by Order №. 92Б/18.10.2024 of the Director of the Institute of Robotics – BAS. She has fulfilled the individual doctoral study plan. All examinations have been successfully passed. Her cumulative credit score for the training is 216 credits, with a minimum requirement of 200. Breakdown by activities: (1) Completion of the educational programme (mandatory minimum 130 points) – achieved 130; (2) Approbation of the implementation of the research programme (mandatory minimum 40 points) – achieved 56; and (3) Publications of scientific results on the dissertation topic (mandatory minimum 30 points) – achieved 30. By decision of the Extended Scientific Seminar dated 02.07.2025 and a report by the Head of Section "RE" at the Institute of Robotics – BAS (incoming №. 231в/02.07.2025), it was proposed to the Scientific Council of the Institute of Robotics to open a procedure for proceeding to defense, which also constitutes de-registration with the right to defend, for the individual

doctoral student Desislava Delcheva. By decision of the Scientific Council of the Institute of Robotics (Protocol № 5/08.07.2025, item 3), the procedure was opened and the Academic Jury was appointed. The entire procedure has been conducted in accordance with the Law on the Development of the Academic Staff in the Republic of Bulgaria, its Implementing Rules, and the Rules of the Institute of Robotics – BAS.

The reviewed dissertation comprises 174 pages of text, 112 figures, and 43 tables. A Declaration of Originality of the results is attached. The author, together with the scientific supervisor, claims two scientific contributions and two scientific-applied contributions.

Submitted materials include: an Author's Abstract of 36 pages, copies of publications related to the dissertation, and other documents as required.

2. Relevance of the Problem Addressed in the Dissertation from Scientific and Scientific-Applied Perspectives

Within the dissertation, classical examples are examined in detail, such as modern drive systems, uninterruptible power supplies (UPS), soft starters for motors, and many others. Power electronic conversion technology is increasingly entering industrial enterprises; power supply systems are becoming polluted, and ideal sinusoidal current and voltage are rarely observed. These modern systems exacerbate problems, particularly with respect to power quality.

The analysis of methods for determining calculated (design) loads and their characteristics enables a more complete, reliable, and accurate determination of the different types of power and the associated losses; this, in turn, allows for more effective approaches to compiling optimal balances of energy indicators and characteristics. Their investigation should be approached comprehensively. Violations of energy balances are most often the result of the irrational operation of power electrical equipment at low, medium, or high voltage; of phenomena arising during fault, transient, and switching processes; as well as of errors and inappropriate control of electrical installations and of the system as a whole. The electric power characteristics and the balance of power can be influenced, on the one hand, by the electric power infrastructure—representing a stationary material substrate with electrotechnical and techno-economic indicators—and, on the other hand, by the electrical energy transferred through this infrastructure, which is also a specific material substrate with its own parameters and characteristics.

The doctoral candidate studies and develops theoretical frameworks for minimizing power losses in power supply systems (PSS). This provides

grounds to regard her work as a relevant and important scientific-applied investigation, particularly suitable for technological transfer.

3. Degree of Familiarity with the State of the Art and Creative Interpretation of the Literature

In assessing the state of the art, the doctoral candidate has used 116 literature sources—41 in Latin script and 75 in Cyrillic—covering the period 1982–2016, which I find logical.

The present work investigates opportunities to rationalize electricity consumption in industrial facilities by seeking an optimal balance between the positive and negative aspects of the process associated with the transfer of electrical energy from generating sources to consumers.

The research in this work was carried out prior to Asst. Eng. Delcheva's joining the research community of the Institute of Robotics at BAS.

My overall impression is that the doctoral candidate demonstrates good awareness in the field. She distinguishes between achievements and unresolved problems, which has served as a basis for the precise formulation of the aim and tasks of the dissertation.

4. Consistency of the Research Methodology and the Stated Aim and Tasks with the Reported Contributions

The aim of the dissertation is to study and develop up-to-date theoretical frameworks for minimizing power losses in power supply systems (ESS), to be applied in the processes of investigating and optimizing the balance of power in industrial facilities and sectors, including techno-economic evaluation of operating modes under a defined optimization criterion. To achieve this aim, the following tasks were defined:

– Investigate methods to optimize the management of power in industrial enterprises in order to improve the efficiency of their electricity consumption;

– Minimize power losses of electrical energy through methods with practically applicable integral characteristics;

– Synthesize a theoretical framework for studying the balance of power in the power supply systems (PSS) of industrial facilities and sectors;

– Optimize the power balance equation under the criterion $\Delta P < 0$ for optimal techno-economic operating modes of the power supply systems (PSS).

My overall impression is that the dissertation is very well structured. The formatting is also at a high level.

I consider that the aim and tasks, as formulated, fully correspond to the achieved scientific-applied and applied contributions.

5. Brief Analytical Characterization of the Dissertation

The dissertation is structured into an introduction, four chapters, scientific and scientific-applied contributions, and references. It meets the requirements of the Law and the Rules for the Development of the Academic Staff of the Republic of Bulgaria for a dissertation for the educational and scientific degree "Doctor."

Chapter One, *"Literature Review on a Broad Range of Issues Related to the Topic of the Work,"* establishes theoretical foundations for determining calculated loads at the stages of design and operation of power supply systems (PSS). The objective was to generate guidance for applying the developed methodologies in determining the different types of power and the losses arising during their transfer, which are constituent parts of the power balance equation when optimizing it. The frameworks have a probabilistic–statistical character.

A conceptual critical approach has been developed for studying power in the power supply systems (PSS) of industrial facilities (IF). The specific features and characteristics of the electric power infrastructure and the electrical energy (EE) transferred through it—viewed as material substrates of one unified system—are examined. The interdependencies among different categories within the electric power domain are analyzed, with trends and directions of their manifestation and realization presented. Some quantitative ratios in this respect are provided. Specific methodological guidelines are outlined for implementing and creating rational approaches to compiling the power balance in both theoretical and practically applicable aspects.

Chapter Two, *"Study and Analysis of Current Theoretical Frameworks for Minimizing Power Losses of Electrical Energy,"* presents a study of the methods for determining conventional power and energy losses. Comparative analysis of the various methods demonstrates the high adequacy, reliability, significance, validity, and congruence of probabilistic–statistical approaches in determining **conventional losses**. In this regard, it is

recommended that, when creating comprehensive methodologies for assessing electrical energy efficiency (EEEf) in the power supply systems (PSS) of industry and of the communal-household sector (CHS), this significant parameter for the electric power sector be included with an appropriate weighting.

A comprehensive multifactor approach based on the Theory of the Design of Experiments (DoE) has been developed, and mathematical models have been obtained for five industrial sectors in the country. This approach has high practical applicability and has been approbated in a number of industrial facilities in industry and in the communal-household sector (CHS).

A method is proposed based on solving an optimization problem under the criterion of minimum equivalent annual costs (EAC) through far-reaching unification of the cross-sections of low-voltage (LV) and medium-voltage (MV) cable lines.

The doctoral candidate maintains the thesis that the research conducted in the country's sectoral structure using the Design of Experiments method provides a solid methodological basis and can serve as a starting point for building concepts for standardizing and forecasting parameters and characteristics of electrical energy efficiency related to power and energy losses.

Chapter Three, "Practically Oriented Study of the Power Balance in the Power Supply System (PSS) of Industrial Facilities and Sectors," formulates the theoretical foundations and justifies the possibility of using the Theory of the Design of Experiments (DoE) to determine static load characteristics (SLC). Long-term active-passive experiments conducted for six sectors in industry and in the communal-household sector (CHS) in the country, at two loading levels β_1 and β_2, enable the determination of static load characteristics (SLC). As a result of probabilistic–statistical processing of the data using DoE, mathematical models (MM) have been obtained, theoretical comparative analyses have been performed, and the influence of the loading factor β on the behavior of the SLC, as well as on characteristic coefficients and regulating effects, has been determined.

Chapter Four, *"Optimal Techno-Economic Operating Modes of the Electric Power System (EPS) under the Criterion δP < 0,"* investigates the achievement of electrical energy efficiency in industry and in the communal-household sector (CHS), which constitutes a multiparameter problem that should be solved under a criterion defined by the inequality $\delta P^* < 0$. As a result of the research, a methodology is proposed for an economical

operating mode of the electric power system (EPS) under this criterion, and optimal regions and ranges of variation of significant factors (SF) are defined.

Through analysis of the research results, the influence of static load characteristics (SLC) on the electrical energy efficiency of different types of consumers, as well as of the electric power system (EPS) as a whole, has been established.

Analyses have been carried out and guidelines and recommendations have been given for achieving electrical energy efficiency (EEEf) in the operation of various electrical installations:

– For installations using electrolysis, the possibility of optimizing the operating mode by regulating the supply voltage has been confirmed;

– A number of appropriate measures for saving electrical energy in electric arc and resistance furnaces have been identified;

– A range of measures and technical opportunities for improving electric welding technology are indicated;

– The possibilities for achieving electrical energy efficiency in compressor and ventilation installations are analyzed in detail;

– A study has been conducted to identify measures for economical consumption by high-power single-phase consumers, with key principles and possibilities outlined for reducing total power and energy losses.

6. Scientific and/or Scientific-Applied Contributions of the Dissertation

The contributions of the dissertation are scientific and scientific-applied in nature and relate to proving existing scientific problems by new means and obtaining confirmatory facts. Original engineering solutions are present. The claims of the doctoral candidate and the scientific supervisor are for two scientific and two scientific-applied contributions:

Scientific contributions

1. A method has been synthesized in a multifactor space for evaluating active power losses depending on four principal factors, enabling the determination of optimal regions with minimal values of the output parameter.

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2. A scientifically grounded method and a probabilistic–statistical approach have been proposed for analyzing the power balance in industrial facilities and in the sectoral structure of the country, by means of which, in a global aspect, a criterion is substantiated for achieving high energy efficiency.

Scientific-applied contributions

3. A practically oriented framework is presented for determining electrical loads in industrial facilities based on the application of a probabilistic–statistical approach in the research process, by which power and electrical energy losses are determined in the most adequate and accurate manner.

4. A methodology has been developed and analyzed for assessing electrical energy efficiency with a view to practical application in the real-world operation of various electrical installations and systems.

I accept, in essence, the substantive content of the above-stated contributions. I consider them sufficient in number and substance for the educational and scientific degree "Doctor."

7. Assessment of the Publications Related to the Dissertation

Five publications have been presented on the dissertation, all co-authored with the scientific supervisor and colleagues from Section "RE" at the Institute of Robotics – BAS.

1. Iliyan Iliev, **Desislava Delcheva**, Rosen Yordanov, "Minimal Losses of Electrical Energy in the Operation of a Power Transformer," *Annual of the University of Mining and Geology "St. Ivan Rilski,"* 2023, pp. 233–236, ISSN 2738-8808.

2. Iliev I., **Delcheva D.**, "Synthesis of a Technical Solution for Compensation of a Capacitive Load." *Energy Forum*, 24–27 June 2025, Sofia. ISSN 1313-2962, pp. 434–440.

3. Iliev I., **Delcheva D.**, "Minimizing Power Losses by Optimizing the Electrical Schedules of Industrial Facilities." *Energy Forum*, 24–27 June 2025, Sofia. ISSN 1313-2962, pp. 419–433.

4. Iliev I., Petrov P., **Delcheva D.**, "Optimal Distribution and Placement of Compensating Power in an International Context." *Energy Forum*, 24–27 June 2025, Sofia. ISSN 1313-2962, pp. 525–535.

5. Iliev I., **Delcheva D.**, "Methodological Framework for Determining the Economic Losses from Deteriorated Power Quality Indicators." *Energy Forum*, 27–30 June 2023, Sofia. ISSN 1313-2962, pp. 322–327.

I find the publications sufficient in number and reflective of the essential part of the results obtained in the dissertation. Based on the submitted Declaration of Originality of the results, I accept the equitable contribution of the doctoral candidate therein and that the dissertation is her own work under the guidance of the scientific supervisor. Evidently, the work of the doctoral candidate has reached the scientific community, as the publications are included in peer-reviewed proceedings of national scientific conferences.

I have not found plagiarism, in accordance with the procedure established by law (Art. 24, para. 5 of the Law on the Development of the Academic Staff in the Republic of Bulgaria), in the scientific works of the doctoral candidate.

I declare that I am not a related party to the doctoral candidate within the meaning of §1, item 5 of the Supplementary Provisions of the said Law.

Although I have known M.Sc. Eng. Desislava Delcheva only recently, I know her as an initiative-taking, energetic, and industrious young researcher.

8. Assessment of the Content and Formatting of the Author's Abstract

The Author's Abstract is formatted in accordance with the requirements. It is entirely based on the dissertation; there are no suggestions or data that are not treated or discussed in the dissertation. The contributions and conclusions in the Author's Abstract coincide with those in the main text.

An English version is also provided.

9. Opinions, Recommendations, and Notes

The author has carried out a substantial volume of work in setting out the research results in detail. The dissertation is very well structured and stylistically prepared. I have not noticed significant errors.

I have noted some minor editorial recommendations on the manuscripts of the dissertation and the Author's Abstract, which the doctoral candidate has reflected in the final version.

The report provided in a **.pdf** file, prepared in accordance with the methodology for assessing the training of doctoral students at BAS under the credit system, was poorly structured. I thank the doctoral candidate for the prompt correction.

10. Conclusion

The aim of the dissertation and its principal tasks have been successfully fulfilled. Positive results have been achieved, amounting to two scientific and two scientific-applied contributions.

The dissertation is written in a sufficiently logical and consistent manner. The results are applicable in engineering practice. They have been disseminated through five publications.

I positively evaluate the completed training with a sufficient credit result. The legal requirements have been met both with regard to the dissertation and to the enhancement of educational preparation and the demonstration of capacity for independent scientific work by the doctoral candidate. Therefore, I propose that the esteemed Academic Jury award to **M.Sc. Eng. Desislava Ivanova Delcheva** the educational and scientific degree **"Doctor"** in the field *5.2 "Electrical Engineering, Electronics and Automation," doctoral programme "Elements and Devices of Automation and Computer Engineering."*

Sofia, 18 September 2025

Reviewer:

/Prof. Dr. Eng. A. Ivanov/

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