

REVIEW
On a doctoral thesis
for obtaining the educational and scientific degree "doctor",
from the field of higher education – 5. Technical sciences,
professional direction – 5.2. Electrical engineering, electronics and automation,
doctoral program – Supply of electricity and electrical equipment

Author: MSc. Eng. Elizabeta Trajko Arsova

Topic: Analysis of the possibilities for the implementation of new photovoltaic power plants in the electricity system of the Republic of North Macedonia.

Reviewer: professor Dipl. Eng. Vasil Dimitrov Dimitrov, PhD
Higher School of Transport in Sofia "Todor Kableshkov",
department "Electricity supply and electrical equipment of transport"

The presented review is according to the Protocol №1 of a correspondence meeting of the scientific jury committee, compiled on the basis of an order of the Rector of the Technical University – Gabrovo, № 3-01-72/22.02.2024 which was taken at the first meeting, held on 26.02.2024.

1. Topic and topicality of the dissertation

The dissertation paper is developed in a volume of 164 pages and includes an introduction, a list of used abbreviations, five chapters, a conclusion, contributions, publications of the author and a bibliography, as well as 4 Appendices (in a volume of 27 pages).

The introduction briefly (2 pages) substantiates the need for the construction for the quality of the electricity infrastructure and the implementation of modern technologies in the energy sector. The objects and methods of the research in the dissertation paper are commented.

In the Chapter one (a volume of 35 pages), special attention is paid to the environmental aspects of the production of the electrical energy and the inevitable needs of the use of renewable energy sources. The balance of the electricity needs and production in the Republic of North Macedonia and the installed capacities classified by technology are considered. At the end of the chapter, it is concluded that the construction of new photovoltaic plants is necessary, since the domestic production of electricity cannot satisfy the needs of consumers, and the geographical position of the country is favorable.

In this connection, **the main goal** of the dissertation paper was formulated, which can be specified as follows:

Analyzing the possibilities for implementing new photovoltaic plants in the electricity system of the Republic of North Macedonia and developing methodologies for design and technical-economic analysis.

To achieve the goals, five main **tasks** are defined, which are successively solved in the following chapters.

In Chapter Two (a volume of 13 pages) the installed capacities and the electricity produced by them from renewable energy sources in neighboring countries (Bulgaria, Serbia and Croatia) are examined, as well as the preferential tariffs. The energy balance of the three countries has been thoroughly analyzed, as a result of which conclusions have been formulated at the end of the chapter about the percentage ratio of the technologies used for the electricity production.

In Chapter three (a volume of 17 pages), a methodology is proposed for researching the potential for the production of electrical energy from photovoltaic power plants by means of modeling and simulation. The software products for studying the potential of solar radiation for the production of electrical energy PVGIS and for designing and simulating the operation of photovoltaic systems PVSyst are described in detail. The PVGIS is online tool enables the simulation of the expected electricity production in the Republic of North Macedonia, and by means of PVSyst it is possible to calculate the optimal location, orientation and placement angle of the panels, as well as the selection of photovoltaic panels manufactured using different technologies.

In Chapter Four (volume of 58 pages), two projects for the construction of new photovoltaic power plants are developed - FEC Bitola (peak power 40 MW_r - in four variants) and FEC Oslomej - 2 (peak power 20 MW_r). The choice of a suitable location and orientation was justified, simulations were carried out with different types of photovoltaic panels, and based on the results, the necessary equipment was selected, which ensures maximum production of electricity for the specific case according to the established criterion of a balance between low cost and good quality. It is possible to connect to the electricity system.

In Chapter Five (a volume of 15 pages), the energy flows during the connection of the newly planned photovoltaic power plants are modeled and analyzed. Simulations and calculations are presented without and with implemented new production facilities. The technical and economic analysis of the investments was made, the payback period was determined.

In the conclusion (4 pages) the obtained results and their application are summarized. Particular attention is paid to the ecological aspect of the development, according to the Directives of the European Union.

In view of the scientific research presented, it can be noted that the topic is extremely relevant: providing new capacities for the electricity system of the Republic of North Macedonia and at the same time improving the ecological situation in the country through the use of renewable sources. With the help of computer modeling, simulations and analysis of the achieved results, specific proposals have been made for the development of photovoltaic plants on the territory of the Republic of North Macedonia. The need for their implementation and the expected economic effect are substantiated. Therefore, the set goals and objectives have been fulfilled and the prerequisites for formulating the contributions of the dissertation work are present.

2. Review of Cited Literature

The bibliography includes 139 literary sources, of which 126 are in Latin and 13 in Cyrillic, including Ordinances, Decrees, Regulations and Development Plans in the field of energy. The significant part of the works were published in the last 25 years (over 85%), but there are also editions from the beginning and middle of the 20th century (eg 57, 61).

Technical literature related to the subject of the dissertation was used. This shows that dipl. eng. Elisabetta Traiko Arsova MSc, is sufficiently familiar with the state of the issue, has in-depth theoretical knowledge of the specialty, knows how to use literary material correctly when conducting scientific research, when working with specialized software products, when analyzing and interpreting the achieved results, which shows an ability to creatively interpret the dependencies known from the literature.

3. Research methodology

The doctoral student has applied an interdisciplinary approach in conducting scientific research and achieving the goal set in the dissertation - joint use of specific knowledge in the field of electric power, electrical equipment, computer modeling and simulation - which is one of the modern requirements for organizing and conducting scientific research. the analysis of the obtained results and the formulation of specific recommendations with a long-term effect.

4. Dissertation Contributions

I agree with the proposed contributions of the dissertation, which are classified by the PhD student as scientifically applied and applied. It is desirable for each of them to note the

corresponding section in which they are discussed and proven. They can be referred to *Creation of new models, methods, structures and technologies; Demonstrating by new means substantial new aspects of already existing scientific fields and problems; Obtaining corroborating facts.*

The results of the conducted research give me the reason to summarize the contributions as follows:

Scientific and applied contribution:

✓ Based on a detailed analytical study of the balance of production and consumption of electrical energy by various technologies and in particular by photovoltaic power plants in four countries on the Balkan Peninsula, reasoned recommendations have been made for the construction of new photovoltaic power plants in the Republic of North Macedonia.

✓ A computer model of the electricity system of the Republic of North Macedonia was synthesized, enabling the analysis of changes in energy flows, energy losses and overvoltages in the power transmission network when connecting the newly designed photovoltaic power plants.

Applied contributions:

✓ The potential of solar radiation for the production of electrical energy from photovoltaic power plants on the territory of the Republic of North Macedonia was investigated.

✓ Developed detailed projects of two photovoltaic plants on the territory of the Republic of North Macedonia with a total peak power of 60 MW_p, using different options of technologies and orientation of the photovoltaic modules.

✓ A technical-economic analysis and evaluation of the profitability of the construction of the two new photovoltaic power plants on the territory of the Republic of North Macedonia was made, taking into account the dependence on the expected prices on the electricity market in the coming years.

It should be noted that the developed models have been analyzed in detail and can be used as a basis for the implementation of the specific proposals made for the construction and implementation of new capacities in the electricity system of the Republic of North Macedonia, using renewable sources.

5. Publications and citations of publications for the dissertation work

The dissertation presents five publications, distributed by indicators G7 and G8, as follows:

One report was presented at an international scientific conference abroad - International Conference on Electronics, Engineering, Physics and Earth Science, EEPES 2023 Conference,

Kavala, Greece, published in AIP Conference Proceedings, referenced and indexed in world-renowned scientific information databases - three authors, the PhD student is the second author. The publication *AIP Conference Proceedings* has an SJR Impact Rank of 0.189/2021 and 0.164/2022. Total number of points according to Indicator **G7 - 13.33 points**.

Two of the publications under Indicator G8 are independent - reports of the International Scientific Conference (7th International Scientific Conference) "TechCo 2023", organized by Technical College - Lovech. Two publications are co-authored with the scientific supervisor (the doctoral student is the first author) - reports of the International Scientific Conference "UniTech 2023", organized by TU - Gabrovo. Total number of points according to Indicator **G8 – 60 points**.

Total number of points under Indicator **G – 73.33 points**, which significantly exceeds the requirement of 30 points.

A Reference for the author's works related to the topic of the dissertation is also presented, before the enrollment of the doctoral student.

The publications reflect major results of the dissertation research and can be considered to have achieved the necessary publicity to the professional engineering community. No publication citation information provided.

6. Authorship of the obtained results

Considering the research presented, combining theoretical analysis and development and simulation of models using modern software products, I consider that the dissertation work was developed to a significant extent by the doctoral student, under the guidance of the research supervisor. Statistical data on the electricity system of the Republic of North Macedonia were used and processed, as well as the peculiarities of the country regarding the possibilities of building photovoltaic plants.

A declaration of authorship is attached to the dissertation.

7. Abstract and author reference

The abstract is structured in a total volume of 43 pages, A4 format. It includes a general description of the dissertation work and an exposition, which is a sufficient sample of the work. The main research, results and conclusions are reflected, as well as the contributions, the publications related to the dissertation, the author's works published before the enrollment of the doctoral student and related to the topic of the dissertation work. An annotation in English is also attached.

Attached are the publications related to the dissertation work, as well as an author's reference for fulfilling the minimum national requirements.

I believe that the Abstract and the author's reference satisfy the requirements and reflect a sufficient part of the achieved results.

8. Opinions, recommendations and remarks about the dissertation work

I have no significant remarks to the presented dissertation work. I have some recommendations and remarks of a technical nature:

- ✓ Some of the titles of individual chapters and sections could be formulated more briefly.
- ✓ Regarding the bibliography - it is good to arrange the literary sources according to the requirements;
- ✓ To specify:
 - Page 2 of the Abstract regarding the structure of the dissertation work (paragraph 2);
 - Table. 2 of the Reference for fulfillment of the minimum national requirements - the scientometric data of the candidate dipl. Eng. Elisabeta Arsova MSc according to Indicator A1.

The recommendations and remarks made do not detract from the development and it is not difficult to remove them in the electronic version of the dissertation and the abstract deposited in NACID.

9. Conclusion

I believe that the presented dissertation meets the requirements of the Law on the Development of the Academic Staff in the Republic of Bulgaria and those of TU - Gabrovo. The achieved results give me reason to **propose** that the educational and scientific degree "**Doctor**" be acquired from the **dipl.eng Elizabeta Trajko Arsova, M.Sc.**

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19.03.2024

Signature: /signature/

/ professor Dipl. Eng. Vasil Dimitrov /